ECLECTIC

PRINCIPLES OF MEDICINE.

AN ELEMENTARY VIEW

OF THE

Causes, Nature, Treatment, Diagnosis, and Prognosis,

OF

DISEASE,

WITH BRIEF REMARKS ON HYGIENICS, OR THE PRESERVATION OF HEALTH.

BY

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PREFACE.

In this work the attempt is made to place the practice of Medicine on a footing somewhat corresponding with that of Physiology, Chemistry, and other sciences which equally depend on the accurate observation and rational arrangement of facts. If our knowledge of the healthy body, and of its parts and functions, be exact, it ought to be our best guide in the study of the same parts and functions in a state of disease. Yet the habit has long prevailed, and even still has its avowed advocates, of regarding the phenomena of disease as a new and separate order of things, the character and laws of which are to be investigated by themselves, and without reference to the standard of health from which they deviate; as if diseases were independent entities, and as if the body under their influence ceased to possess the same structures and tions which it has in health. Happily, however, irrational dogmas do not now find much favour with members of our profession, who, in proportion as they become more enlightened by sound physiology, recognise in it, when combined with careful clinical and pathological observation, the best guide to the understanding and treatment of disease.

It must be admitted that there remain considerable doubt and obscurity in many subjects, both in Physiology and in Medicine; and the science of one and the art of the other must, therefore, still be acknowledged to be imperfect; but no one can dispassionately look back on the progress which has been made in both departments within the last thirty years, without being encouraged to hope for increasing precision in the science, and greater success in the art.

For an additional proof of the existence of a growing interest and confidence in rational medicine, I may perhaps be excused in referring to the success of the former editions of this work. When first I communicated to my Publisher my intention of bringing out a work on the Principles of Medicine, I was by no means encouraged by the intimation that books on that subject did not sell; but no sooner was it discovered that the "Principles" were essentially and intelligibly *practical*, than the demand for the work became sufficient to exhaust two editions long before I could find time to replace them. Several editions have also appeared on the Continent and in America.

I have now to express my regret that the incessant engagements of my practice have so long delayed the appearance of this edition. In fact, it might have been deferred much longer if I had not secured the valuable assistance of my friend and former pupil, Dr. R. J. Mann, who has contributed several articles on recent investigations in Physiology and Animal Chemistry, and has taken great pains in revising the composition of the whole work.

To my friend, Mr. George Gulliver, I am also indebted for looking over the chapters on Diseases of the Blood, and Inflammation, and for very important microscopic contributions on these subjects. Free reference has been made to various recent authors on Physiology and Pathology; but I would especially mention the works of Dr. Carpenter, Mr. Paget, and Professor Rokitansky, as sources from which I have derived much valuable information.

It is right to mention that several of the early sheets of this work have been printed more than twelve months, which will account for the absence from them of reference to the most recent facts.

49, Upper Brook Street,
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PRINCIPLES OF MEDICINE.

EXPLANATION OF THE OBJECT OF THE WORK.

1. The Principles, Elements, or Institutes of Medicine consist of those leading and general facts and doctrines regarding disease and its treatment, which are applicable, not to individual cases only, but to groups or classes of diseases. The same branch of medical knowledge is also designated by the term General Pathology and Therapeutics, to distinguish it from Special Pathology and Therapeutics, or the theory and practice of medicine in relation to individual diseases.

2. The principles of medicine may be deduced in part from a knowledge of the animal structure and its functions (anatomy and physiology), conjoined with an acquaintance with the agents which cause and remove disease; they are chiefly arrived at by a generalization of the facts observed in an extensive study of disease itself, whether these be effects manifested in the living or in the dead body. But so far as they have been ascertained, they become more intelligible to the student if explained synthetically, that is, by describing first the causes of disease, then the operation of these on the body, and lastly, the resulting changes in function or structure which constitute the more elementary forms of disease.

3. Etiology, or a knowledge of the causes of disease, appropriately introduces the consideration of the effect—*disease* itself; the nature and constitution of which may then be conveniently considered under the head of pathogeny, or pathology proper. This last subject is the one to which I design to chiefly direct attention, and therefore, it will occupy the greater part of the work; but it will be also combined with such an elementary view of the

principles of treatment (GENERAL THERAPEUTICS), as reason and experience may supply.

4. A short general view will afterwards be given of the phenomena of disease (SEMEIOLOGY),—of the division and classification of diseases (NOSOLOGY),—of their detection and distinction from each other (DIAGNOSIS),—of the indications of their probable results (PROGNOSIS),—and of their prevention (PROPHYLAXIS and HYGIENICS).

DEFINITION OF DISEASE.

5. The reader is presumed to be acquainted with anatomy and physiology: without such knowledge not even a definition of disease can be formed. Disease is known only by comparing it with the standard of health, which it is the object of anatomy and physiology to describe.

Health consists in a natural and proper condition and proportion in the functions and structures of the several parts of which the body is composed. From physiology we learn that there are certain relations of these functions and structures to each other, and to external agents, which are most conducive to their well-being and permanency; these constitute the condition of health. But this knowledge implies that function and structure may be in states not conducive to permanency and well-being: states which are deviations from the due balance between the several properties or parts of the animal frame; these states constitute *disease.* For example, physiology, as well as experience, teaches us, that in health the digestion of food is easily performed and attended by sensations of comfort. But when, after food is taken, there is pain, uneasiness, sickness, eructation, flatulence, or the like, we know that the *function* of digestion is changed from the healthy standard—is *diseased;* and if this diseased function continue long in spite of the employment of remedies which usually serve to correct it, and if on examining the abdomen we find at or near the epigastrium a hard tumour, which anatomy teaches us is not there in health, we know that there is also *diseased structure.*

6. We find, then (§ 5), that in this case there is *disease of function,* known by its deviation from a standard furnished by *physiology;* and also *disease of structure,* which is recognised by departure from a standard supplied by *anatomy* (§ 5). These

different kinds of disease may be, and very commonly are, combined: there is seldom structural disease without some disorder of function; and in many instances functional disease is, or ultimately will be, accompanied by change of structure.

7. Looking, then, to anatomy and physiology as expressing the standard of health, we may define *disease* to be, *a changed condition or proportion of function or structure in one or more parts of the body.*

8. The standard of health is not, however, the same in all individuals: that which is health to one may be disease to another. Thus to instance individual functions:—The healthy pulse in adults averages from 70 to 80; yet there are some in whom 90 or 100 is a healthy pulse. Some persons fatten on a quantity of food on which others would starve. Muscular strength and activity, nervous sensibility, and the sensorial powers, vary exceedingly in different individuals, yet all within the limits of health: what is health in one would be decidedly morbid in another. Unusual proportions of the different structures or functions to each other constitute varieties of temperament; and although these can scarcely be called morbid, yet they certainly give, as we shall afterwards see, a proclivity to disease. Thus predominance of sensibility and excitability of the excito-motory nerves over other vital functions, constitutes the nervous temperament, which is compatible with perfect health, although it predisposes the individual to diseases of a nervous kind. A preponderance of the nutritive functions renders a person florid and bulky, although in perfect health; but this carries with it a risk of exceeding the bounds of health, and of inducing plethora and obesity, to such an extent as to interfere with the well-being and order of the bodily functions, and so to constitute disease.

CHAPTER I.

ETIOLOGY—THE CAUSES OF DISEASE.

SECTION I.

NATURE AND DIVISION OF CAUSES.

9. Causes of disease are such circumstances as essentially precede it, and to whose operation its occurrence is due. In many instances these circumstances elude our observation. In many others, the true cause, if apparent, is combined with other circumstances which have no share in producing the result, disease, and which yet are thence liable to be mistaken for causes. These circumstances are to be sifted, and the true cause discovered, only by the attentive observation of large numbers of cases, in which disease is produced. The non-essential circumstances will then be found to be sometimes absent, and that which is always present may consequently be fairly regarded as the influential cause. But this, as before stated, sometimes eludes observation; in this case, as well as in elucidating the operation of circumstances supposed to act as causes, the most useful knowledge may be obtained by investigating the ultimate nature of the disease itself, which will often throw light on its own source. Thus it was at one time a matter of doubt whether the itch could be engendered from filth, as well as from contagion; but since microscopic investigation has discovered the existence of the itch-mite, no doubt remains that this insect is the only essential cause of the disease, however its operation may be promoted by filthy habits.

10. The causes, or circumstances, inducing disease, may be *intrinsic*, or existing within the body, independently of any obvious external influence; or they may be *extrinsic*, having their origin without the body. As examples of intrinsic causes may be mentioned excess or defect of some function (such as irritability), or of some constituent of the body (such as the blood). Extrinsic causes are very numerous; they comprise indeed all the external

agencies which can operate on the body or mind, such as temperature, air, moisture, food, poisons, mechanical and chemical influences, and sensual impressions.

11. A great variety of agents and circumstances may thus act on the body so as to produce disease; but in most instances it seems as if there were not that uniform and constant relation between these causes, and the diseases that result, which we might expect from the analogy of the operation of causation in the simpler sciences. In chemistry or in mechanics obvious effects certainly and uniformly follow obvious causes; in physiology or pathology, no doubt, certain fixed effects also follow certain determinate causes; but whether these effects become manifest as disease or not, depends on many circumstances, of which often we can take no cognizance. When the causes are of the same nature as those which are operative in physics or chemistry, the expected effects never fail to ensue. Thus, a cutting instrument, a red-hot iron, or a corrosive liquid, invariably produces disease, when applied, because its physical or chemical operation is so energetic that it overcomes all vital properties. Certain poisons and other analogous potent agents, which act on, without destroying, the vital properties of living parts, also, if of sufficient strength, pretty constantly produce morbid effects. Thus, opium taken internally causes somnolency; tartar emetic excites nausea and vomiting; cantharides applied to the surface induce inflammation, &c.

12. But the most common causes of disease are seldom of this decided and positive character; they are often present without disease ensuing; and they are known to be causes only because disease is observed to ensue in a greater number of cases when they are present, than when they are absent. Thus, improper food is a cause of indigestion, and exposure to cold is a cause of catarrh; yet many persons eat unwholesome food without suffering from indigestion, and many are exposed to cold without "taking cold." But those, who *do* suffer from indigestion, observe that they do so more certainly after taking improper food; and those who *are* affected with catarrh can often trace it to exposure to cold. The reason for this uncertainty of action is chiefly found in the difference of power which the body exerts in resisting the morbific influence; this power varies much under different circumstances. Its failure, or irregular operation, constitutes a predisposition to disease.

15. In some cases, however, what is in a smaller degree a predisposition may, when it exists in a greater degree, constitute alone a sufficient cause of disease (§ 11): thus a person with a very weak stomach always has indigestion, whether an exciting cause be applied or not. So likewise exciting causes, if sufficiently strong, may produce disease without predisposition: thus a person not predisposed to indigestion may be pretty sure to earn it, if he take a sufficient quantity of fat, raw cucumber, pickled salmon, or any such indigestible matter. Take another example. A healthy person living in a marshy district may not get an ague, until he becomes debilitated by any cause, such as cold, or fatigue: then the poison will act. But without his being thus weakened, if the exciting cause be made stronger by his sleeping on the very marshy ground itself, then the poison may act without predisposition, and the ague begins (§ 12).

16. The consideration of these facts throws some light on the nature of predisposition viewed as a cause. There is in organised beings a certain conservative power which opposes the operation of noxious agents, and labours to expel them when they are introduced into the body. The existence of this power has long been recognised, and in former days it was impersonated. It was the *archæus* of Van Helmont; the *anima* of Stahl; the *vis medicatrix naturæ* of Cullen. Now without supposing it to be aught added to the ordinary attributes of living matter, we may note its operation in the common performance of excretion: we see it in the manner in which the noxious products of the body, and the useless constituents in food, are ejected from the system; in the flow of tears which washes a grain of dust from the eye; in the act of sneezing and coughing which remove irritating matters from the air passages; and in the slower, more complicated, but not less apt example of inflammation, effusion of lymph, and those suppurative actions, by which a thorn, or any other extraneous object, is removed from the flesh.

17. This *vis conservatrix* (§ 16) is alive to the exciting causes of disease; and in persons in full health it is generally competent to resist them. How it resists them depends on their nature. For instance:—Is cold the cause? If so the blood is thrown inwardly; and this, exciting the heart to quickened action, establishes a calorific process, which removes the cold. Is the cause improper food? The preserving power operates by discharging the offending matter speedily by vomiting or by stool. Is it a malarious or contagious poison? It is carried off by an increase of some of the secretions. But if the resisting power (§ 16) be weakened, locally or generally, or if the exciting cause be too strong for it, then the cause acts, and disease begins (§ 15).

18. In the cases hitherto noticed, predisposing causes consist in absence or deficiency of power (§ 16), rather than in the existence of anything positive: but sometimes predisposition to disease depends on something positively wrong in function or structure, which yet alone scarcely amounts to disease; and this fault may be congenital, or hereditary, or acquired.

19. It must be observed that predisposing causes operate chiefly through the general system or constitution; hence they are often called *constitutional* or *internal* causes, in contradistinction to the exciting causes, which are more commonly *external*, or

acting from without. But these terms are objectionable, because not always applicable. Sometimes the term *predisposing* is also inappropriate, as in the following instance. Several persons are exposed to a malarious or infectious poison: some of these afterwards suffer from great fatigue or privation; they then begin to show the effects of the poison: but the others who have not tained this second influence, escape unhurt. The poison h entered the system in both cases; but in the latter its influence resisted; while in the former the subsequent weakening so redu the powers of resistance that the system yields before the exciting cause; but occurring after, this weakening cannot be said to *predispose*. Hence, under such circumstances, the fatigue or privation is called the *determining* cause.

Dr. Carpenter defines a cause to be a "force or power operating under certain definite material conditions,"* in other words he considers the antecedents necessary to produce a result as being of two kinds, dynamical and material. But these do not necessarily correspond with exciting and predisposing causes of disease, for a variation of force may constitute predisposition, and on the other hand alterations in material may become exciting causes. The fact is simply that the division of causes ordinarily adopted among pathologists is conventional and convenient rather than natural and philosophical. What are called causes are really circumstances that are essentially and invariably antecedent to disordered action. Some single circumstance may alone be discoverable; or there may be two, three, or more, that have been acting simultaneously, or in succession. It is often convenient to specify some of these circumstances as predisposing the body to become diseased, others as determining the disease, and others as exciting or calling it up. But it is not always easy to say which ought to be termed a predisposition, which a determination, and which an excitement. The study of pathology and medicine is more difficult and uncertain than the study of ordinary physics, simply because the results observed are nearly always consequent upon a combination of manifold causes, which are always varying in an infinite diversity of ways. Causes follow effects in the vital actions of the living body as certainly and as surely as they do in the working of the dead masses of Nature, but these causes are interwoven in a more complex way, and are subject to many more modifications. The

* "Principles of Human Physiology," 1853, p. 5.

results observed in pathology seem to be uncertain merely because the observer has an imperfect knowledge of the antecedents and of their workings. When the properties of organized material, and the actions of living substance are as thoroughly understood as the properties of crude and unorganized matter, the organic sciences will be found to be as precise as Physics properly so called.

SECTION II.

PREDISPOSING CAUSES OF DISEASE.

20. What for convenience sake we agree to call predisposing causes of disease are circumstances which so influence the functions or structures of the body as to render that body unusually susceptible to the influence of particular exciting causes. Predisposing causes are, however, in strict accuracy, different from predisposition. Predisposition is the state of the body which is brought about by the operation of these causes. Predisposing causes make the body unusually susceptible of certain diseases through predisposition in its structures or condition. Now the most important circumstances that operate in this way may be advantageously considered under the following heads.

I. DEBILITATING INFLUENCES.
II. EXCITEMENT.
III. PREVIOUS DISEASE.
IV. PRESENT DISEASE.
V. HEREDITARY CONSTITUTION.
VI. TEMPERAMENT.
VII. AGE.
VIII. SEX.
IX. OCCUPATION.

I. DEBILITATING CAUSES OF PREDISPOSITION are the most numerous of all. This might be anticipated from the fact that constitutional strength generally implies power of resisting disease (§§ 16, 17). The circumstances which are most influential in this way are such as enfeeble the heart, impair the tone of the arteries, and reduce the activity of the secreting organs: often too

an unusual susceptibility of the nervous system, which increases the liability of the body to suffer. The following are the chief agents of this class.

21. (*a*). *Imperfect nourishment*, either in consequence of defect in the quantity or quality of the food, or of incapacity of the digestive powers. This in itself causes many diseases, particularly of digestion and nutrition; but it also weakens the power of the general system to resist cold, and produces a liability to low fevers, inflammations, and epidemic, contagious, and endemic disorders. Thus the increased susceptibility of the body to the influence of cold and infection, when fasting, is generally acknowledged; the rapid propagation of infectious diseases among an ill-fed population, like the poor Irish, is but too well known; and to the disgrace of our nation it must be acknowledged that insufficient and unwholesome food has been one of the unhappy circumstances that have contributed to render our brave troops in the Crimea an easy prey to disease and death in various forms. The same cause, too, especially lays the body open to the injurious influences that induce zymotic disorders. The offensive odour of the breath and excretions on the approach of death from starvation, proves that there is depravation and incipient corruption in the materials of the body, as well as weakness.

22. (*b*). *Impure air.* The injurious effects of this are manifested in the pallid, cachectic complexion of the inhabitants of crowded cities, even of those who live well and regularly. How strikingly this contrasts with the ruddy countenance of the hardy and coarsely-fed mountaineer! So are the former also distinguished in the greater liability of these classes to diseases, particularly to those of the organs of respiration, circulation, and nutrition. No circumstance seems to operate more extensively in favouring the spread and increasing the virulence of such pestilential diseases as the plague, typhus, malignant scarlatina, and the measles, than impurity of air. It effects this in two ways. In the first place it weakens the body, and so acts as a true predisposing cause. But in the second place it leads to the concentration and increased virulence of the poison itself, which is diluted and destroyed by the influence of ventilation and fresh air. The imperfect performance of the processes of respiration and cutaneous transpiration in small and close habitations makes persons offensive both to themselves and to others, in consequence of corrupt matter which ought to be

eliminated being left in the system. This makes the soil fertile (so to speak) for the fostering of the seeds of disease, although it may alone be inadequate to the production of disorder. The evil influence of over-crowding human dwellings has been abundantly and forcibly illustrated during the prevalence of epidemic cholera in our own and foreign lands.*

23. (*c*). *Excessive exertion of body or mind.* Moderate exercise is beneficial to both body and mind; but when either in degree or continuance, this exceeds what the strength can bear or rest can recruit, the animal functions become exhausted, and lose their balance; muscular tone is impaired, nervous excitability takes the place of strength, the circulation fails, congestions ensue, the blood is not properly purified, and the various organs get to the brink of disease. It is hence that the fatigued mind or body is peculiarly prone to succumb before causes of disease. It has been observed in India that regiments were especially liable to be attacked by prevailing epidemic and endemic disorders when suffering from fatigue after forced marches. This has been sadly exemplified in the disastrous results of the siege of Sebastopol, where excessive fatigue in addition to cold and privation destroyed thousands of the British army. Want of sleep has a similar effect; and when the body is extremely exhausted, even sleep, which is nature's best restorer, is disturbed by the imperfect performance of circulation and respiration through excess of weakness, hence there is a liability to insomnia and nervous excitement in states of exhaustion.

24. (*d*). *Want of exercise and sedentary habits* generally also favour the production of disease. The healthy vigour of the various functions of body and mind is best maintained by equal and moderate exercise; and the torpor of inactivity renders them more obnoxious to the causes of disease. The muscular function, and the circulation of blood, are the first to suffer; hence first sluggish movements, and ultimately weakness, of the heart and other muscles. The defective circulation too tells most in parts at a distance from the heart, producing cold extremities, dry skin, inactive liver, with its frequent concomitants, hæmorrhoids, torpid bowels, and indigestion: whilst at the same time the heart itself, and the organs near to it, may be oppressed and injured by an undue load of blood, especially if the subject be plethoric; hence palpitation,

* See Mr. Grainger's Report on the State of certain Parts of the Metropolis, &c., 1851. Also "British and Foreign Medical Chirurgical Review," January 1, 1853.

dyspnœa, headache, vertigo, somnolency, dulness of the senses, &c., &c. In nervous subjects convulsive affections are often produced by this inequality of circulation. The respiration being little exercised, the task of decarbonising the blood is imperfectly performed; or devolves more on the liver; hence the accumulation of fat in the textures, and the occurrence of bilious derangements. From this statement it will be obvious that sedentary habits, if excessive, may alone be equal to the production of disease, and that where they exist in less degree they may predispose to its production by other causes, such as irregularities of diet, exposure to cold, violent exertion, &c. From such combination of influences arise various disorders of the digestive organs, heart, lungs, and brain; catarrh, gout, rheumatism, calculous affections, diseases of the skin, &c.

25. (*e*). *Long-continued heat.* The debilitating effects of this agent are abundantly exemplified in warm climates and seasons. Under its influence, the muscles, and with them the heart and arteries, lose power and tone; the textures become relaxed; perspiration is profuse: and internal organs, especially the liver, are too much stimulated by blood which has lost more than its usual amount of water, and less of its hydro-carbon. Hence arises a disposition to bilious and liver complaints, dysentery and cholera. The function of respiration is much less active in an atmosphere at a high temperature, than when it is cooler. Less oxygen is then taken into the body, and the effete products of decay are less rapidly carried off by oxidation. The odour of the perspiration and other secretions thence becomes strongly offensive, and the blood is kept in a state prone for the reception and propagation of zymotic morbific agencies. Overheated rooms and excessive clothing predispose to disease in the same way by their weakening and relaxing influence. It may be remarked that most of the diseases of hot climates and seasons occur rather at the termination of the greatest heat, than during its steady prevalence, and that therefore this predisposes to, rather than excites, the disease, which is really the immediate effect of cold, or of irregularity of diet, or of malaria. Thus the bilious diarrhœa and cholera of this country occur chiefly in the early autumn, when the cool of the evening is strongly contrasted with the heat of the day. The chill suddenly arrests the perspiration, and throwing the blood inwardly, oppresses internal organs, especially the liver, whose resisting and reactionary energies have been exhausted by the influence of the

previous heat: hence coldness of the surface and congestion of the liver and portal system, precede the more active symptoms in flux, cholera, diarrhœa, dysentery, &c.

26. (*f*). *Long-continued cold.* The experiments of Chossat and others clearly prove cold to be a direct sedative, capable of reducing all the vital powers. Cold applied suddenly and for a short time, invigorates, because it then induces a healthy re-action, by which the vital properties are exercised and exalted. But when long continued, its own sedative and debilitating effects are permanent: it weakens the circulation, especially that of the surface, causes internal congestions, and directly depresses all the vital energies. The most malignant forms of epidemic fever in this country prevail towards the close of very severe winters; and all diseases then frequently assume a typhoid type. This is observed chiefly among the lower orders, whose means do not enable them to protect themselves sufficiently against the inclemencies of the season. We have before adverted to the striking manner in which cold disposes the body to suffer from malaria (§ 19).

27. (*g*). *Habitual intemperance in intoxicating liquors.* There is probably, in this country, no source of disease more fertile than this. Besides many disorders which are directly excited by it, it predisposes to attacks of fever, erysipelas, dysentery, cholera, dropsy, and rheumatic and urinary diseases; and if it do not increase the proneness to inflammatory disorders, the habit of intemperance certainly disposes such affections to unfavourable terminations, and causes many a victim to sink after accidents and operations, which would have been comparatively trifling affairs in more sober subjects. Nor can we wonder at the pernicious effects of this kind of excess, when we consider the weakened state of function and structure which stimulating drinks induce, especially in the organs which they most directly affect, the stomach, the liver, the kidneys, the blood, the heart, and the brain. We shall soon have to explain how unsound states of these organs thus induced peculiarly impair the powers of the body to resist or throw off disease (§ 17).

28. (*h*). *Depressing passions of the mind, such as fear, grief, and despondency.* Many are the instances in which bodies of men, as well as individuals, have escaped a prevalent disease, until depressed by some unhappy event or apprehension, and then have fallen victims to it. This was exemplified in the ill-fated Walcheren expedition, as well as in many incidents in the history of other

armies in pestilential countries. A defeat, a failure, or even bad news, have made hosts succumb to the pestilence, who had before escaped. It is a common remark, that when a contagious or epidemic disease prevails, those who take most precautions frequently suffer most, because they are timid and fearful; the stout-hearted and reckless escape unscathed. Persons whose mental and bodily functions are sustained by confidence and courage, or are excited by enthusiasms, are much less prone than others to suffer from the depressing influence of fatigue, cold, wet, malaria, and infection. Anxiety and great mental exertion tend to waste the tissues of the body, and in doing so they not only weaken the frame, but load the blood with excrementitious matter, which may become a nidus for the propagation of zymotic poisons.

29. (*i*). *Excessive and repeated evacuations, either of blood or of some secretion.* The weakening effect of a large loss of blood needs no explanation; but the injurious influence of habitual losses or drains, when these are more than the system can simultaneously repair, is however even greater; for the vital functions then become depraved as well as depressed, a state of cachexia as well as anæmia is induced, and very trifling causes suffice to determine grave states of disease. Menorrhagia, diarrhœa, leucorrhœa, and other hæmorrhages and fluxes, if excessive, reduce the powers of life and the capacity to resist disease. No loss of this nature, however, weakens so much or so irreparably, as excessive secretion of semen. In many of the lower tribes of animals, the males live till they copulate, and then die: the reproduction of the species is at the expense of the individual. That our own species is not wholly exempt from this law of organised nature, is apparent from the fact that immoderate venery produces extreme debility and premature decay, and predisposes body and mind to various diseases.

30. (*j*). *Previous debilitating diseases.* It is well known that the body is unusually liable to contract fresh disorder during convalescence from serious maladies. It is then weak in all its powers; and the nervous system often obtains the ascendancy which is common in states of weakness, and which renders the body unusually susceptible to mischief (§ 23); improper food, exertion, excitement, or exposure to cold, at such times readily produce the former or some new complaint. Hence convalescence from a severe disease is a state requiring peculiar care. The functions are just resuming their balance, and have neither the vigour of

action nor the power of resistance which is the attribute of robust health. The diseases which leave the body most liable to this species of derangement are those ending in exhaustion; as continued fevers and protracted and severe inflammations.

31. II. Hitherto we have considered only those circumstances which predispose to disease through a weakening influence (§§ 16, 17, 20). There are, however, other circumstances of a somewhat opposite character, which favour the production of disease through STATES OF EXCITEMENT OR ACTIVITY. Full living, without an adequate amount of exercise, often brings the circulation and other functions up to a high pressure degree of activity without producing disease; there is then redundancy of health, and a more than usual capability of resisting those causes of disease which operate by depression, such as cold, malaria, and infection. But there is a predisposition to suffer from causes of additional excitement; thus irritants then more readily induce inflammation; violent exertion causes hæmorrhages; and the stimulation of almost any organ may heighten the vital actions to a morbid pitch (§ 5—8). So, also, unusual vascular activity in a part, although insufficient to produce positive disease, may render the part more liable to suffer upon the supervention of external causes. Thus the determination of blood to the uterus and mammæ at certain periods renders those organs then more liable to disease. Violent exertion makes the muscles, or their fasciæ, peculiarly prone to rheumatic inflammation on the application of cold and damp. Excessive indulgence in stimulant diuretic beverages, (such as punch), renders the kidneys liable to inflammation or congestion on exposure to cold. Inflammation or irritation of the intestines is not a common effect of cold, but often becomes so when these viscera are under the exciting influence of a purgative. The brain, if previously over active from hard study, may be excited into inflammation by alcoholic stimulus, or strong moral emotion.

32. III. Proclivity to disease is not unfrequently a consequence of PREVIOUS DISEASE, independently of the mere weakening influence already noticed (§ 30). This is particularly instanced in some inflammatory and nervous disorders. Thus, a child who has once had croup is very liable to its recurrence. One attack of enteritis frequently predisposes to another. Convulsive disorders,

such as chorea, hysteria, and epilepsy, are extremely apt to recur; and the longer they have existed, the more difficult are they to remove, and the more ready are they to reappear on the application of any exciting cause. This, which may be called a habit of disease, it is most important to prevent. There can be little doubt that the previous attack, in all such cases, leaves some change of structure or function (§ 18), which constitutes the predisposition, although it may be of a nature to elude our means of detection.

33. Under this head may also be arranged many constitutional predispositions to disease which are ascribable to the persistence in the system of a cause of some previous attack rather than to the attack itself. Rheumatism, gout, gravel, many cutaneous diseases, dropsy, and jaundice, may be quoted as examples. A person who has once suffered from any of these is very liable to a recurrence on the application of an exciting cause; and this is because, although free from the first attack, he may not have lost some functional or structural imperfection (§ 18) which was the predisponent to that attack, and which may therefore again produce a like result upon the addition of an exciting cause. In most of these cases the constitutional defect is in some of the processes of assimilation or excretion, and generally of a functional nature, but occasionally it is also attended with change of structure, especially in the great eliminating organs, the liver, the intestines, and the kidneys.

Nor can we separate from this class of constitutional causes certain (§ 32) predispositions to structural disease, of a tuberculous and malignant nature. Where products of this kind have once appeared, there is a tendency to the production of more, although such tendency may be latent until brought into activity by an exciting cause. In the following pages many arguments will be found which favour the view that the disposition to such disorders is connected with faulty functions of assimilation and excretion.

34. IV. Disease already existing in the body, even when itself latent, often predisposes to other disorders, independently of its mere weakening effect. (§ 20). Thus tubercles and other tumours, structural lesions of the heart and other organs, often induce irritations or obstructions of blood-vessels, which, if not the cause of immediate and manifest disease, nevertheless lead the way to the production of disorder by other causes. A person on the

occasion of violent bodily exertion (vocal or otherwise) is seized with profuse spitting of blood, which causes his death: on opening the body many tubercles are found in the lungs, although there had been no obvious symptoms of their existence before the violent effort. Or, again, disease of the heart causing accumulation in the veins, often leads to congestion of the lungs and liver; and it may only require the addition of an exciting cause, such as sudden exertion or an excess in diet, to bring about an attack of asthma or jaundice. These are instances of causes coming into operation by accumulation. Granular disease of the kidneys, which impairs the excreting power of these organs, renders the body more liable to suffer disease through the operation of infectious and other poisons, as well as of other exciting causes. Febrile and inflammatory diseases often leave in the body more or less of effete material, which is prone to decomposition, and which sets up derangement in the blood, skin, mucous membranes, and other structures, on the application of any trivial exciting cause, thus causing eruptions, fluxes, and analogous mischief.—The dregs of one malady, in this way, prepare the body for the occurrence of a second.

Dr. Carpenter* has recently pointed out a probable *modus operandi* of the predisposing causes of Zymotic disease, (see Section IV.) which connects itself with the matters under consideration. Such disorders as puerperal fever, erysipelas, yellow fever, eruptive fevers, cholera, and dysentery are observed to be most readily propagated, as well as to assume more grave characters, in proportion as an albuminous material prone to decay, abounds in the body, whether it be introduced from without, or result from the disintegrating processes of the system; in either case being retained in consequence of the imperfect action of the excretory or eliminating apparatus. —Such decomposing principle (then in fact equivalent to a diseased condition of the fluids) becomes a predisposing cause of disorder, and renders the body obnoxious to infection from the influence of the slightest amount of morbid poison. This is well seen in puerperal females; when the uterus is undergoing a process of rapid disintegration in such, it is especially prone to contract the state that leads to the disorder known as puerperal fever, from any medical attendant who has been in close connexion with the disease either in the living or dead subject. Those who are suffering from accidents or surgical operations are in the same way liable to catch

* "British and Foreign Medico-Chirurgical Review," January, 1853.

erysipelas and a peculiar form of adynamic fever, which are, according to Professor Simpson, capable of being carried from patient to patient by the hands of the surgeon, and which are then capable of producing the same morbid states in other subjects.

The debilitating influences already noticed, imperfect nourishment (§ 21), impure air (§ 22), excessive exertion (§ 23), and habitual intemperance (§ 26), predispose to Zymotic diseases, not only by their general depressing agency, but also by impairing the condition of the blood, and by increasing in it the quantity of an azotized matter in an incipient stage of corruption, and serving as an appropriate nidus for the propagation of a morbific poison. In all cases of this kind, the predisposition must be referred to a morbid state already present in the system.

35. The predisposing causes hitherto considered may be called accidental or acquired. There are, however, other influences which are present in the individual at birth; and yet others which arise from circumstances of age or growth. All these may be referred to something defective or ill-balanced in the organization (§ 18), but which is insufficient to manifest itself actively until wrought upon by an external exciting cause.

36. V. Of the predispositions present in the individual at birth, the most generally recognised is HEREDITARY TENDENCY TO DISEASE. It is well known that scrofula, gout, rheumatism, epilepsy, mania, asthma, blindness, and deafness, run in families. That this depends on individual peculiarities transmitted from parents to offspring, appears from the fact that all children do not partake alike of the disposition. Nay, sometimes a generation is free from a disease, which was present in the ancestor and appears again in the offspring. So too we see external organization, family likeness, differently stamped on different children of the same family.

It must not be supposed that hereditary proclivity to disease commences at birth. In a few instances it is congenital; but in a greater number it is developed by growth or some other circumstances in life. Gout, for example, is acknowledged to be hereditary; a parent has it in middle or advanced life: the son does not get it until about the same period, a little sooner or later, according to whether he lives freely or not. Here is something

which is transmitted from father to son, and yet not manifest in the son for forty or fifty years.

37. VI. Frequently, but not necessarily, connected with hereditary conformation, is the peculiarity of constitution called TEMPERAMENT, which certainly predisposes to particular diseases. Temperament consists in a predominance or defect of some function or set of functions, viewed in relation to others (§ 9).

38. Thus the *sanguine* temperament implies an activity of the system which circulates florid blood, and a full proportion of red corpuscles; it is manifested by an excitable pulse, flushing cheek, quick movements, and lively disposition. This temperament gives a predisposition to inflammation, determination of blood, and active hæmorrhage (30).

39. The *phlegmatic* or *lymphatic* temperament is the reverse of the sanguine: it occurs in those who have a weak pulse, languid circulation, cold extremities, and pallid skin,—there is a deficiency of florid blood, and of vascular action and tone (§ 9), and the proclivity is to watery fluxes, dropsy, and other chronic affections.

40. The *bilious* or *melancholic* temperament, is commonly met with in persons of dark complexion and gloomy disposition; there is probably here defective action in some of the biliary or digestive organs, which are therefore the more liable to derangement (§ 9).

41. The *nervous* temperament is externally manifested only by agitation or trepidation of manner; it seems to depend on an excess, or want of right proportion, of some of the properties of the nervous system (§ 9), and predisposes to the disorders called nervous, such as hysteria, nervous pains, and spasms. These temperaments may be variously combined.

The word *diathesis* is often used to express a particular morbid tendency; thus we hear of the inflammatory diathesis, the scrofulous diathesis, &c. It is merely another word for disposition, and affords no clue to the nature of the thing spoken of.

42. VII. The last group of predisposing causes to be noticed relates to AGE. The several changes in organization, as well as in external circumstance, which the animal frame undergoes at different periods of life, may naturally be expected to be attended with corresponding variations in the proclivities to disease. I pro-

ceed to enumerate a few of these, premising that some of the examples may be entitled to rank with exciting causes of disease, as well as with predispositions.

43. (*a*) *In early infancy*, the low calorific power of the body disposes it to suffer readily from the bad effects of cold (§ 17), whence the tendency at that time to visceral inflammations. The skin is particularly liable to various eruptions in consequence of its tenderness and its not being habituated to the new and drying medium in which it is placed. The redness of new-born children is obviously the result of the irritating action of the air; it often assumes the form of a vivid erythema, and is followed by desquamation of the cuticle, and a yellow stain of the skin beneath, from extravasated hæmatosin, which is sometimes erroneously thought to be a kind of jaundice. Strophulus and other papular eruptions often succeed. The comparatively unused state of the alimentary canal at birth renders it also peculiarly susceptible of disorder; another trial awaits it at the period of weaning—hence arise diarrhœa, vomiting, colic, waterbrash, atrophy, and other ailments connected with disordered digestion. The brain, excited by the novelties of the external world, becomes rapidly developed, and, in its increased activity and growth, is rendered liable to various diseases (§ 30); hence the proclivity to hydrocephalus, convulsions, &c. The process of teething adds an irritation, which acts on the nervous system, the bowels, and the air passages, and disposes them to get readily disordered.

44. (*b*) *In childhood, or the age from infancy to puberty*, the functions most active are such as administer to growth: the organs of digestion and assimilation are therefore obnoxious to disorder (§ 32); hence the frequency of derangements of the stomach and bowels, worms, infantile remittent, &c. The activity of the nutritive function gives a preponderance to the protein constituents of the blood; and inflammations which incidentally occur are commonly attended with the effusion of much plastic or albuminous matter; as seen in the products of croup, and mesenteric disease, tubercle, &c. The natural mobility (or activity of the excitomotory system) of childhood predisposes to chorea and kindred affections (§ 30).

45. (*c*) *Puberty* brings with it many morbid susceptibilities, but especially in the female sex, in which the important function of menstruation is then established. Many and serious are the

evils which are liable to be produced by external causes, that tend to check the development of this function. This function when established has its nervous as well as its vascular relations; and hence, where it is irregular or disordered, a predisposition is given to many maladies affecting the blood-vessels and their contents, the secreting organs, and the nervous system.

46. (*d*) *At the termination of growth,* there is another critical period. The cessation of the appropriation of nourishment to the increase of the body, may, in the more robust, cause fulness of the vessels, and a disposition to hypertrophy, hæmorrhage, and inflammation; and in the cachectic, it may lead to morbid depositions, especially of the tuberculous kind (§ 47). The same redundancy of the vivifying fluid in active circulation, gives that buoyancy of animal spirits and impulsive energy of feeling and strength, which are the characteristics of healthy youth; yet this very exuberance of vital power, if not properly controlled and balanced, constitutes a tendency to disease; either directly, as where excitement, rising beyond the limits of health, borders on morbid action (§ 31); or indirectly, as where excessive exertion leads to subsequent exhaustion (§ 23). Youth is the age of susceptibility to moral and physical impressions; and therefore of liability to the disorders which these are capable of producing.

47. (*e*) *Adult age* can hardly be said to predispose to any diseases, unless it be such as arise out of the mode of life then pursued. It is commonly a period of comparatively steady health, because the functions are then very evenly balanced; but if the mode of life be unfavourable, bad habits are apt to become established, and by their continuance to induce disease. Thus gout, gravel, rheumatism, indigestion, and various other disorders, are apt to occur in middle life, because the predisposition to them is then gradually engendered (§ 24) by some error in diet or regimen, too slight to excite disease at once, but sufficient by accumulation to dispose to it, and so to allow of its being manifested on the application of some exciting cause.

As *age* advances, such habits as overstrain and exhaust the strength of the organs, begin permanently to affect the organization, accelerating those changes by which human existence is limited to a span of years. This occurs sooner in proportion as the powers of the system have been expended by hard and irregular living, bodily hardships or mental anxiety, and later accordingly as prudence

and moderation have been the guides; different people manifest marks of senility, and senile disposition to disease at very various periods of their lives. It would occupy too much space to enter into a detailed account of these changes, but some of the principal of them may be briefly noticed, as illustrating the peculiar weaknesses and liabilities of *advanced age.*

48. (*f*) The changes which *old age* induces in the exterior of the body are connected with a failure of those functions which are most active in youth. Instead of muscles, fat, and integuments being nourished in the several proportions that give beauty as well as strength to the form in mature life, the muscles get thin and sinewy; fat becomes scanty, partial, or in excess; the integuments are loose and wrinkled, or fat and flabby; the joints stiffen, and the gait loses its firmness and uprightness. These changes in the textures of the body are attended, and probably induced, by altered relations in the different parts of the vascular system. The pallid skin of age, contrasted with the ruddy blush of youth, indicates the diminished development of the capillary blood-vessels, that great system, which sustains the life and nutrition of the body; much of the blood that in earlier age circulated on the surface, giving vigour and sensibility to all the external organs, and life and susceptibility to all outward relations, becomes accumulated in the interior, and confines its vivifying and nutrient influence chiefly to the internal functions and structures, thus tending to render the individual more isolated and selfish. But the blood that is kept back in the larger vessels, is not equally distributed within them. The diminished capillaries intercept some of the force by which the nutritive fluid is propelled through the arteries: hence it stagnates and accumulates in the veins, which become distended and tortuous; but the arteries, being at the same time exposed to the continued impulsive force from the heart, lose much of their elasticity, and become rigid tubes, thus causing the peculiar hardness of the senile pulse. The nutrition of the textures generally fails, not in degree only, but in kind also, and chemical transformations and deposits begin to show themselves in the different structures. The fibrous and muscular tissues exhibit partial conversion into fatty matter, and osseous or petrifactive changes encroach on many structures of low organization; there is a tendency to degradation towards the composition of mere vegetable and mineral matter.

This altered condition of the blood-vessels brings with it morbid

tendencies, the nature of which will depend much on the state of the great moving power, the heart; now more than ever the prime agent in the circulation. If the heart be moderately strong, a fair balance may long be sustained; although hæmorrhoids, varicose veins, and such results of local obstructions, may occur. If the heart be too strong, (which is often the case after a life of much muscular exertion,) the small arteries frequently suffer from the unsoftened force of its pulses, particularly in the brain, and there is a liability to apoplexy or palsy: the same thing in mucous membranes forms a disposition to active fluxes, catarrh, asthma, and affections of the urinary organs. The more vascular textures, especially of internal organs, are over nourished, and increase in size or weight. If the heart be weak or diseased, there will be imperfect circulation and tendency to venous congestions, dropsical effusions, imperfect and disordered secretions, altered nutrition, and a general failure of all the functions which depend on a sufficient supply of arterial blood: diseases of the liver, stomach, kidneys, lungs, and other viscera arise in this way: in extreme cases the lower extremities actually die for want of circulation.

If instead of the organs of circulation we were to take the alimentary, the respiratory, or the urinary apparatus, we should also here find changes induced by age, which show that man's organization is only intended to last a limited time. Old age is thus attended with increasing infirmities and liabilities to disease (§ 16, 18). The very strength and activity which some functions retain, may, in consequence of their partiality, endanger life; but their gradual and more equal failure degrades the physical, and often the mental, frame of man to a lower scale of existence, until he sinks into second childhood, dotage, and decrepitude.

49. VIII. Sex. The liability which sex gives to the diseases of the respective generative organs is too obvious to need mention. But the peculiarities of sex are not confined to the generative organs: they extend to many other of the structures and functions of the body.

The male sex is peculiar in the higher development of the muscular and voluntary excitomotory system, and a corresponding strength of frame;—in the stronger impulses of the animal passions; and in the greater endowment of the reasoning faculty. These respectively bring with them a liability to suffer from dis-

eases of the muscles, limbs, joints, heart, and great vessels;—from the evils contingent on undue indulgence of passion or appetite; and from disorders of the brain and its intellectual functions.

In the female sex the predominant bodily functions are the nutritive, the sensitive, and the involuntary excitomotory; and the perceptive and instinctive faculties, and moral emotions, preponderate in the mind. Hence the greater proneness of females to changes in flesh and blood; to disordered sensation, spasm, convulsive and other affections of the spinal system; and to the direct and indirect consequences of the indulgence or thwarting of instinctive and moral feelings. The predisposing influences of the menstrual function have been before noticed (§ 45); it may now however be added, that its cessation favours the development of various diseases of function and structure, especially growths, simple and malignant.

50. IX. Occupation comprises many circumstances already noticed under the heads of predisposing influences. Thus sedentary occupations imply want of exercise (§ 24), and sometimes impure air (§ 22); laborious employments operate like excessive exertion (§ 23); other occupations predispose to disease by the continued exposure to heat (§ 25) or cold (§ 26). Some employments require constrained postures, which if insufficient to induce, may yet promote the occurrence of disease; thus engravers and watchmakers are liable to affections of the head, because they hold it low; shoemakers and tailors are subject to disorders of the stomach, because they compress it during their work. In many other instances particular occupations induce disease rather by exposing the individuals to the exciting causes, than by inducing a predisposition; but as before remarked, the very circumstances, which, when in great intensity suffice to excite disease, when acting in a lower degree may only induce a disposition to derangement. Thus the slow introduction of lead into the system, so commonly occurring in the occupations of painting, plumbing, card-enamelling, and printing, *may* not cause colic until cold or irregularity of diet becomes an additional or exciting cause. The same remark applies to dry grinding, needle-pointing, leather-dressing, and other unhealthy occupations. The time during which such employments are pursued is an important element in the result; thus an occupation, not in itself unhealthy, may become so when continued too many hours in the day; and a work which is attended with risk may be

often safely undertaken for short periods, a due amount of relaxation or diversion to another pursuit being allowed between. By attention to this point, the injurious influences of occupations may be much lessened.

SECTION III.

EXCITING CAUSES OF DISEASE.

51. We now pass to the consideration of *exciting causes* of disease; that is of such circumstances and agents as seem to be operative in producing disease in the body, more especially when in a state of predisposition (14). It has been stated before (§ 11, 15), that certain powerful agents, of the nature of irritants or poisons, pretty surely cause disease, independently of peculiarity of constitution or predisposition; but peculiar constitution or predisposition may even then modify the character of the disease in different cases: where the exciting agents are less powerful, as in the case of most common causes of disease, the effects depend still more on the influence of predisposition, and may be altogether inappreciable when this is not strong (§ 15, 19).

Exciting causes of disease, then, are certain external circumstances which have been observed to be very frequently present when certain diseases occur. Because the diseases seldom appear unless these circumstances have been present, they have come to be considered as essential to the result, and in the light of excitements to it. Hence they are designated exciting causes. Now such influences may be conveniently distributed into two divisions, as COGNIZABLE and NONCOGNIZABLE agents. The former class comprehends physical and mental influences, of whose existence we can take cognizance, independently of their operation in producing disease; thus cold we know by its effect on our instruments and organs of sensation; muscular exertion, by our witnessing or making it; and mental emotion, by our consciousness of it. The *noncognizable* causes, on the other hand, elude our senses, and we infer their existence only from their morbific effects: thus malaria and infection are only observed in their morbific results. The subjoined table specifies the different kinds of influences that are comprised within these several divisions.

- Exciting Causes of Disease.
  - I. Cognizable Agents.
    1. Mechanical influences.
    2. Chemical influences.
    3. Ingesta.
    4. Bodily exertion.
    5. Mental emotion.
    6. Excessive evacuation.
    7. Suppressed or defective evacuation.
    8. Defective cleanliness, ventilation, and drainage.
    9. Excesses and changes of temperature.
  - II. Noncognizable Agents.
    1. Endemic
    2. Epidemic
    3. Infectious

    } Poisons.

I. COGNIZABLE AGENTS.

52. (1.) *Mechanical causes, which injure structure; or impede, or derange, function.* Besides the obvious instances afforded in tearing, cutting, pinching, striking, and straining, which produce at once diseases that fall within the province of the surgeon, there are also many mechanical sources of mischief that come under the physician's notice. Long-continued pressure of articles of clothing sometimes produces disease. Tight neckcloths may cause headache or even apoplexy, by impeding the flow of blood from the head. Tight stays may produce fainting, by pressure on the heart and great vessels, and colic and costiveness and other disorders by obstructing the free passage through the great intestines. Pressure on the epigastrium after a meal, caused by sitting at a desk, may excite indigestion. Long continuance in one position, whether standing, sitting, or lying, tends to obstruct circulation and innervation, and to produce swelling and paralysis of the parts of the body that are beyond the seat of pressure, and this in time may even cause inflammation and death of the parts pressed upon. But mechanical causes may also be operative within the body. A stone in the bladder irritates by its mechanical properties, especially if it be of an angular shape; or it may mechanically stop the flow of urine: so also may a gall stone stop that of the bile. The intestinal canal is sometimes mechanically obstructed by hardened fæces, until irritation and inflammation ensue. The stomach is often mechanically irritated by the bulk, hardness, or asperities of its contents: and vomiting, indigestion, or inflammation of the organ, may be thereby induced. The air-passages of needle-pointers, stone-masons, &c., are irritated and inflamed, and at

length become altered in structure, in consequence of the mechanical action of particles of stone or other substances, which these men inhale in the course of their employment.

Instances of this kind are endless: certain of the structural effects of disease also exercise considerable mechanical influence. Tumours, diseases of the heart and vessels, the lungs and air-passages, intestines; and urinary apparatus, and injuries and diseases of the bones and ligaments, afford abundant illustrations of this mechanical causation of disease.

Some mechanical injuries, when extensive, besides their simple effects on structures and functions, directly depress the vital powers; thus, concussion of the brain, crushing or tearing off a limb, or a blow on the epigastrium, induces fainting and extreme weakness of the heart's action, and may thus even cause death. Slighter mechanical injuries are causes of irritation or excitement, which may be local or general, according to the excitability and extent of the part irritated.

53. (2.) *Chemical causes* of disease are even more varied than mechanical, because the several chemical agents are more numerous than the mechanical. We are acquainted with the chemistry of the animal body less than with its mechanism, and therefore can the less clearly distinguish causes which act by chemical properties, from those which have complex relations to vital properties, than we can those which are mechanical. But we recognise chemical irritants in acids, alkalies, and many salts, whether applied to a part, or inhaled in form of gas or vapour. So what are called chemical poisons, such as corrosive sublimate and other metallic salts, the strong acids and alkalies, iodine, chlorine, &c., produce disease by their known powerful chemical affinities, which tend to decompose tissues and disorder functions.

We cannot doubt that many of the matters which cause disease in the alimentary canal, do so by virtue of their chemical qualities. The process of digestion, although always in part chemical, is so under the superintendent influence of a superior vital power: no sooner does this power fail, or the chemical agencies or decompositions become too strong for it, than we have fermentation and putrefaction, which cause eructation of gas or sour liquid from the mouth, and there may follow the discharge of ill-coloured and unusually fœtid matters by stool; then too, may arise a number

of disorders, which may in great part be referred to the influence of these injurious chemical processes.

There appear to be at least four modes in which chemical agents may excite disease in the body:—

1. By acting as *local irritants,* as do the diluted acids, alkalies, and various salts, the chemical operation of which is resisted by increased action excited in the part (§ 16).

2. By acting as *corrosives,* as in the case of strong acids, alkalies, some metallic salts, chlorine, and iodine, which by their powerful chemical affinity, so completely overcome the vital affinities of textures as to decompose them and thus to kill and alter the condition of the part.

3. By acting as *septics,* promoting the decomposition of the fluids or solids of the body, in the same way that ferments or putrescent matters operate on dead organic matter

4. By acting as *chemical alteratives,* modifying the changes which take place in digestion, assimilation, transformation of textures, secretions, &c., as instanced in the counteraction of acidity by alkalies, in variously influencing the state of the blood and urine by acids, alkalies, &c.; and in causing the production of hippuric acid in that excretion, by the administration of benzoic acid, and the increase of the solid constituents of the urine by the administration of salt, in the increase of the sulphates by the exhibition of liquor potassæ, (Parkes); &c.

The operation of chemical agents on the general system will vary according to the intensity of their action, and the extent of their application. Irritants, if extensively applied, cause feverish excitement. Corrosives, if acting widely, depress the vital powers, like the shock of violent mechanical injuries (§ 52); if more partially, the vital powers are excited to resist them, thus corrosives operate as irritants. Septics, if very powerful, may speedily overwhelm the preserving vital powers of the body, which then speedily passes into a state of corruption, as in the case of extensive gangrene, pestilential diseases, &c.: but if the septic matter be scanty, and the vital powers strong, they are excited to increased action, and the body may by means of accelerated circulation, and augmented excretions, get rid of the offensive matter (§ 17). Such kind of struggle is instanced in typhoid fevers, epidemic cholera, and dysentery, and other toxic diseases, which have received the appellation of *zymotic,* from the supposed resemblance of their cause to a ferment.

54. (3.) *The solid and liquid ingesta* are a fertile source of disease, and this in various ways. Their mechanical and chemical properties have already been noticed, (§ 52, 53.) But, they may also cause disease—

a. As non-alimentary matters acting injuriously.

b. As aliment faulty, or ill-proportioned, *in quality.*

c. As aliment defective, or excessive, *in quantity.*

55. (*a*) Of the *non-alimentary matters* contained in the ingesta, that are capable of exciting disease, salt, spices, pickles, and other condiments, and spirituous or fermented liquors, are illustrations. They are all more or less irritating or stimulating to the digestive apparatus; and if used indiscreetly may induce inflammations, congestions, and functional disorders of these organs, and, in some instances, irritation of other parts, and of the whole system. Salt in moderation is beneficial as an adjunct to food, both on account of its antiseptic and solvent properties, and as supplying a part of the acid for digestion, and an alkali which is required in bile and other fluids: but if in excess, it irritates the stomach, retards digestion, and causes feverishness with thirst. Much of these effects is due to the affinity of the salt for the water of the animal fluids, and may be induced by other saline matters beside common salt. Wherever excess of salt is contained in the body, there will be osmosis* and exosmosis of the liquid amidst the adjoining vessels and tissues until the salt is equally distributed among them, and before this is accomplished, there will be such a diminution of the fluids within the blood corpuscles, and on the surface of membranes, as will readily account for the thirst and disturbance caused in the system. According to Liebig, salt impedes the deposition of fat. Animals will not fatten on salt food;—this is a hint for the corpulent. Salt increases the elimination of urine by the kidneys; it has therefore been supposed to hasten the destructive metamorphosis of tissues. The absence of salt in food, especially if this be vegetable, favours the production of worms in the intestines.

56. Alcoholic liquors act as stimulants when taken into the stomach. At first they provoke appetite and enable the organ to dispose of a greater quantity of food; but soon the digestive power fails in consequence of the exhaustion that necessarily follows undue excitement, and inappetency, nausea, or even vomiting ensues. The operation of these agents is, however, soon extended,

* Professor Graham; "Proceedings of Royal Society," 1854.

for they are absorbed into the blood, and their stimulant action is exercised on distant parts, especially on the vascular and nervous system. As the absorption is effected by the veins, they pass by the portal vein directly to the liver, and hence the function and structure of this organ are particularly apt to suffer from indulgence in spirituous beverages. So too as the kidneys are the natural emunctories through which extraneous matters are eliminated from the system, they get first over-stimulated, and then exhausted, and are injured in their secreting power, and ultimately in their structure also, if repeatedly exposed to the same injurious influence. The heart and vessels also are over-excited at first, and afterwards lose their tone: the processes of assimilation and nutrition are impaired and modified, and all the solids and fluids of the body become in some degree depraved. The nervous system suffers especially from the disordering influence of intoxicating liquors. If a large quantity is taken at one time, it acts as a narcotic poison, inducing a short period of cerebral excitement or intoxication, and then insensibility, in which the functions of the brain are more or less completely impaired, and in extreme cases those of the spinal marrow also; if the influence be insufficient to stop respiration, yet it may so far interfere with it as to lead to congestions in the brain and other organs. Hence apoplexy, palsy, phrenitis, or delirium tremens, may follow, and the whole frame may suffer from the effects of the poison. Even when less excessive quantities are taken, the headache, sickness, inappetency, and feelings of wretchedness and depression which commonly ensue, sufficiently prove that grave disorder has been produced, and that such artificial excitements cannot be abused with impunity.

Habitual indulgence in strong drinks causes other kinds of disease, which are so often seen that they deserve especial notice. When taken only, or chiefly, with food, not as a substitute for it, but as a constituent of general "free living," fermented liquors contribute to the production of an abundance of ill-assimilated, overheated blood:* which either finds a vent in eruptions on the surface, or in local hæmorrhages or fluxes, or causes various func-

* This effect of alcoholic drinks, familiar to all observers, receives additional illustrations from the experiments of Dr. Böcker, which show that they tend to diminish the urinary excretion, and the elimination of carbonic acid by the lungs.—*British and Foreign Medico-Chirurgical Review*, October, 1854, p. 398.

tional disorders, such as palpitation, vertigo, stupor, dyspepsia, and bilious attacks, or sometimes produces gout or gravel. The latter results more commonly follow when the beverages contain much free acid, as well as an abundance of spirit, as is the case with port wine, rum punch, and hard strong beer. The less acid malt liquors, ale and porter, tend rather to induce liver disorders, and an abundant deposition of fat in the body. All these consequences are promoted by sedentary habits (§ 24) and deficient excretion: for active exercise carries off much of the spirit and superfluous aliment, by an increased elimination through the aids of respiration and perspiration.

The most disastrous consequences of intemperance are exhibited in the habitual drunkard, who in proportion as he indulges in liquor, loses his appetite for food, and his power of digesting it. He then drinks and starves at the same time; and the disease which ensues comprises the exhaustion of inanition together with the more direct effects of the alcoholic poison. Thus in delirium tremens, the drunkard's disease, besides the permanent restless excitement of the irritated nervous system, which adds more and more to the exhaustion, there is fearful weakness of mind and body; and in bad cases even the organic functions are affected, so that the pulse is very weak and frequent, the excretions are scanty and depraved, and the respiration is so imperfectly performed by the involuntary powers that sleep cannot ensue. This exhaustion soon terminates in death, unless the result is prevented by appropriate treatment; and this must comprise, besides opium (the common remedy), ammonia and other stimulants to the circulation and respiration, purgatives and diuretics to free the blood from the excrementitious matter that has accumulated in it; and fluid nourishment to repair its waste. Without these adjuncts, opium will not only fail to procure sleep, but if given in large doses may even paralyse the remaining powers of life.*

* Long experience has fully convinced me of the danger of an empirical mode of treatment in the worst forms of delirium tremens. I have known more than one instance where death has speedily and unexpectedly ensued upon the administration of opium in large doses, ordered to be "repeated until sleep should be procured." When it was procured, it proved to be the sleep of death. Inability to sleep, in this disorder, depends upon the exhaustion of the medullary and nervous powers, as named above, and perhaps also somewhat on the vitiated state of the blood, which gets loaded with decaying and excrementitious matters that the depressed secerning energies are not able to eliminate.

Pernicious as fermented liquors are in their abuse, yet these and other adjuncts to food when taken with careful moderation and discrimination, often prove beneficial by aiding the digestion where it is weak, and by counteracting various exhausting and depressing influences, which frequently arise out of the artificial condition and employments of society, especially in large towns and in cold climates. It appears from the observations of Dr. Böcker, that alcoholic liquors used in moderation, prove beneficial in restraining the waste of tissues, and therefore in sustaining the nutrition of the body. In this respect its action is contrasted with that of water and of salt, and resembles that of tea and coffee. (*Brit. and For. Med. Chir. Rev.* Oct. 1854.) Total abstinence, therefore, is preferable to moderation, in many cases, rather because it is morally easier to practise, than because it is more salutary in its physical effects.

Tea and coffee also, although refreshing and really invigorating adjuncts to food when used in moderation, may excite disease when taken in excess: the derangements being chiefly those of the stomach and nervous system. Gastralgia, nervous palpitation, or fainting, insomnia, and even mental delusions, have been induced by the too free use of strong tea or coffee. Even water, the simplest, and it might be thought the most harmless of beverages is not without its positive influence on the animal œconomy, and if taken in excess, is capable of producing considerable disorder. Besides its effect in distending the alimentary canal and blood-vessels through which it passes, it further accelerates the retrogressive transformation of the blood and textures, as is manifest by the increase of matter excreted by the kidneys and intestines. (Böcker, *ut supra.*) It appears, therefore, that water largely taken tends to reduce the weight of the body, and impoverishes the blood, whilst alcoholic liquors have the opposite effect.

57. Disease may be excited by unwholesome articles with which

Here stimulants, instead of increased narcotization, are the things needed; and even tonics may be of service, combined with nutrients in the form of soups, jellies, and farinaceous foods, and also diuretics and aperients. These should be given during the day, and the opiates reserved for the night; and even moderate doses, under such circumstances, often prove to be efficacious. I have sometimes found better results follow from the use of tincture or extract of Indian hemp (which, however, are not always obtainable of definite strength) than from that of opium, for it calms the nervous system and induces sleep, without impairing the appetite or powers of digestion. The tincture of hop, too, is a useful adjunct to other remedies in this point of view.

the food is adulterated. To this class of causes belong various poisons; the operation of some of these will be noticed under the head of Modes of Death (See chapter on Prognosis); but for further details, works on toxicology and materia medica must be consulted. There are some noxious matters occasionally mixed with food, which produce deleterious effects very gradually. In this way salted provisions, too long used, cause scurvy: ergotted corn has been known to produce dry gangrene. Lead gradually introduced into the system causes constipation, colic, paralysis, cachexia, anæmia and atrophy. Impure water used as drink, is a common cause of disease. River or pump water near towns often contains decaying vegetable or animal matters, and induces sickness, diarrhœa, dysentery, cholera, and typhoid symptoms. Hard waters, which are impregnated with some of the salts of lime, render the bowels costive, and are supposed to favour the production of calculous diseases and bronchocele: brackish waters, containing saline matter, may induce dyspepsia and diarrhœa: chalybeates, containing iron, are constipating and heating.—Any kind of impure water, if long used as drink, may gradually impair the processes of digestion, nutrition, and assimilation, even although no obvious disorder immediately results from their use.

Under the head of non-alimentary ingesta which may cause disease, we must reckon various medicines; and that not only when injudiciously administered, but even as commonly prescribed: the remedies *necessary* to cure or relieve many diseases are not uncommonly *necessary evils;* they remove one disorder by inducing another, and it is well when the evil thus induced is the smaller of the two. It cannot be denied that proofs are frequently met with of the mischievous and morbific effects of the injudicious employment of drugs, and there can be no doubt that many of the boasted achievements of homœopathy, and other quackeries, are really the result of the suspension of the influence of injurious medicinal agents.*

* Dr. Mann in revising these pages has favoured me with the following illustration:—"A very interesting case of this kind has just fallen under my notice. I was called last week to see a physician, a visitor to this place (Cromer), for relaxation. I found him in a state of great nervous excitement and trepidation, and full of the idea that he was just going into a state of collapse. On investigating the facts I found he had been taking immoderate exercise in the sun, and eating lobsters and drinking pale ale, until attacked with bilious derangement, and mild continued fever; then he fancied he had suffered from malaria, and that the fever had distinct intermissions, so he dosed himself with quinine.

58. (*b.*) Unfitness in the quality of aliment is another condition whereby ingesta may cause disease. Man is by nature and habit an omnivorous animal; and in general his health is best maintained by an admixture of different qualities and varieties of animal and vegetable food. The insalubrity of the simpler constituents of food, when used separately, even those supposed to be most nutritive, has been well shewn by the numerous experiments of Majendie, Gmelin, and others. They fed dogs, geese, donkeys, and other animals, on articles which are generally considered highly nutritive, as sugar, gum, starch, oil, or butter; when any of these were given exclusively, the animals died with symptoms of starvation almost as soon as if they had been kept without food. Even bread, when too fine, is unsuitable for exclusive nutriment. A dog fed on pure white bread lived only fifty days, whereas another fed with the coarsest brown bread was well nourished, and seemed capable of living an indefinite period. According to the researches of a commission of the French Institute, (the report of which was published in 1841,) animals fed on pure fibrin, albumen, or gelatine, die of starvation, and with reduced quantity and depraved quality of the blood, almost as soon as if not fed at all. Gluten, or vegetable albumen, seemed to be the only simple principle which was able alone to maintain life. The nutritious qualities of vegetable food depend chiefly on the quantity they contain of this azotized principle. Wheaten bread consists of this highly nutritious principle combined with a due proportion of combustible and heat-supplying starch. Hence it is the most sufficient and useful of all the varieties of food, and may therefore well be called the *staff of life*. Even animal albumen and fibrin require mixture with vegetable matter to make them properly nutritious as well as wholesome; and gelatine and oily matters are still less available for nourishment without some such combination. In the experiments just alluded to, animals could be supported for a lengthened time on meat or flesh, which comprises several of the elementary principles, although they could not be sustained by any one of these principles given alone.

The utility of a due combination of the organic elements in the food used by animals was long since sagaciously pointed out by

When I saw him he had taken sixty grains of disulphate of quinine in a few hours; the nervous derangement was unquestionably due to the influence of the medicinal agent. It was four complete days before the disease thus induced had disappeared."

Dr. Prout, who takes the natural aliment of infancy, milk, as the great type of all proper kinds of nourishment; as it contains albumen, oil, sugar, and water, (not omitting certain salts, especially the chloride of sodium, and phosphate of lime,) so all other kinds of food ordinarily used for sustenance ought to include these elements, or others isomeric (that is, identical in ultimate composition) with them; and it is certainly true that all combinations of food sanctioned by custom do comprise such ingredients. Bread contains two of them, gluten, which is vegetable albumen, and starch, which is isomeric with sugar; but bread is not relished without butter or some fat with it. Neither does meat, which contains albumen and fat, suit the taste without combination with bread, rice, potatoes, or some vegetable, which represents the amylaceous or saccharine principle. The palate likewise craves the addition of a little salt, which promotes the digestion and assimilation of most kinds of food.

59. Much discussion has occurred of late as to the share which each of these constituents of food takes in the actions of the animal œconomy, and the extent to which they can be changed by the process of digestion and assimilation. Dumas, and the French chemists generally, have maintained that the digestive process only separates and appropriates principles ready formed in the food, and that it does not effect the conversion of one into another. Thus they say that all the albumen or fibrin in the body is derived from the albumen or gluten of the food; and all the fat from fat or oil contained in the nourishment. This view, so far as fat at least is concerned, is opposed by many familiar facts, such as the fattening of domestic animals with farinaceous and vegetable foods, which contain very little fat; and it has been completely negatived by the experiments of Petroz and Boussingault, which have proved that geese and pigs during the process of fattening gain more fat than is contained in their food.* It further appears probable that the conversion of sugar into fat is promoted by the agency of bile; for H. Meckel found that by keeping a mixture of bile and grape sugar at a warm temperature, the quantity of fat in the mixture increased to double in five hours, and more than treble in twenty-four hours. It is pretty certain, therefore, that fat may be formed out of starch or the saccharine principle, and probably from the albuminous also, as albumen gets

* Dr. Day's Report on Chemistry in Dr. Ranking's Abstract, July 1846, p. 316.

spontaneously converted into fat under special circumstances. But there is no decisive evidence to show that albumen or gelatine is elaborated from fat, starch, or sugar, at least under common circumstances; and it is certain that these elements alone do not suffice to sustain animal strength or life.*

Baron Liebig has, in a very comprehensive hypothesis, suggested that food not only supplies the plastic constituents whereby the waste of the textures is repaired, and their growth supplied, but that it also furnishes the chief combustible principle of the blood, which is burned under the process of respiration for the support of the animal temperature, and thus protects the histo-genetic (or tissue-making) materials from being consumed. Thus whilst albumen, fibrin, and analogous matters are applied to the purposes of growth and nutrition, oil, sugar, starch, alcohol, and allied matters, like gum and vegetable acids, constitute merely combustive material, or fuel, which is converted, through the oxidating processes of respiration, into carbonic acid and water, giving out heat during the change. It is certain, however, that fatty matter is, in a degree, essential to nutrition, being a constant constituent of the nuclei and granules of the primary cells of tissues and of nerve substance. So also as starch and sugar are susceptible of being converted into fat by the agency of the liver, they cannot be excluded from the list of nutritive materials. It is scarcely possible to doubt that the increase of weight and muscular strength that accrues from the continued employment of cod-liver oil can be anything else than a result of direct nutrition by means of oil.

60. The chief alimentary matters may be classed into groups, accordingly as they are *albuminous, gelatinous, oleaginous,* and *saccharine* or *amylaceous:* we have now briefly to consider how an excess, or defect, and in some instances faulty quality, of either of these, may operate in causing disease.

Albuminous or *proteinaceous* articles, such as the lean of meat, fowl, and fish, gluten of bread, and casein of milk, supply the albumen and fibrin of the blood, and of the textures of the body.

* In a very able paper on Vital affinities, by Dr. Alison, (Transac. of Royal Soc. Edin. 1847,) many arguments are adduced in favour of the inference that albumen may be formed in the animal body, especially in vigorous health: the author suggests that ammonia may be the source from which starch and other non-azotized articles of food receive the azote that is necessary for their conversion into albumen. There is much reason on the side of this notion: it may be seen that I have long entertained a similar opinion with regard to the conversion of gelatine into albumen.

Hence *deficiency* of this kind of nourishment will produce, first, weakness of the heart and other muscles, and then wasting of these, and of other textures, with diminution of the quantity and richness of the blood. Failure of muscular strength, weakness of the circulation, and wasting of the muscular and other structures, commonly result from insufficiency of albuminous foods. *Excess* of carneous food, particularly of the richer kind, butcher's meat, tends to oppress and derange the digestive organs, or to cause plethora, with excited circulation and feverishness, which may even result in hæmorrhage, inflammation, gout, lithiasis, &c.

Bad quality of albuminous food is peculiarly injurious to persons of weak digestive and assimilative powers: thus the casein of cheese, the fibrin of stale or salted meats, and the gluten of sour or ill-baked bread or heavy pastry, may irritate the alimentary canal and cause dyspepsia and diarrhœa, and even when absorbed, instead of forming good protein material, may degenerate into certain products of animal decay, namely, lithic and lactic acids, urea,* &c. Hence may arise gout, rheumatism, calculous disorders, cutaneous eruptions, low irritative fever and cachexia.

Gelatinous foods, soups, broths, isinglass, and jellies, are by no means so nutritious as albuminous matters; but when combined with bread they satisfy hunger and nourish the body so well that it seems very probable that in a healthy constitution gelatine may assist in the formation of albumen; but when used in excess, or to the exclusion of bread and meat, it ceases to be nutritious, and the strength and flesh waste under its use.

Oleaginous nutriment, butter, fat of meat, oils, and oily seeds, not only supply the material for the adipose textures of the body, but also assist in the formation of other structures and secretions, (oil globules forming a normal constituent in them,) and afford the strongest fuel for the maintenance of animal heat by respiration. From what has been before stated (§ 59), it may be inferred that fat may also be formed from saccharine and starchy food, as well as drawn from the storehouses of the adipose membrane: and

* In this statement I disregard the dogma of Liebig that the materials of food serve for respiration and nutrition only, and that urea, lithic acid and excrementitious matters are derived from the decay of the tissues alone. Daily observation convinces the medical practitioner that in persons of weak assimilation, certain articles of food, so certainly and promptly cause an increase of animal matter in the urine, that there can be no doubt they are the direct sources of the addition. The observations of Lehmann support the same conclusion.—*Physiological Chemistry;* translated by Dr. Day, 1851, vol. i. p. 161.

from the researches of M. Claude Bernard it appears that the liver has the power of elaborating both fat and sugar out of the constituents of the blood when neither of these principles is supplied in the food.* Still *deficiency of fat* in the food has been observed to induce the following morbid results: loss of flesh, and of the rounded plumpness and smoothness of the surface, which becomes skinny, wrinkled, and often dry and scurfy; brittleness of the hair and nails; deficient secretion of mucus at the orifices of mucous passages, of cerumen in the ear, and of synovia in the sheaths and joints; insufficient formation of bile, and consequent impaired digestion and flatulent fœtid and irregular fæculent excretion; with diminution of the power of sustaining animal heat. On this account the privation of oily food is more injurious in cold seasons and climates than in the reverse, often even aggravating the morbific operation of external cold. *Excess of fat food* may disorder the stomach by its indigestibility, becoming rancid, and causing heartburn or sickness, and sometimes a bitter bilious taste; for much fat seems to induce a regurgitation of bile into the stomach, probably to assist its digestion (Beaumont) and absorption (Matteucci). If the fat is carried into the blood, it may cause inconvenient obesity by its accumulation in the adipose texture of various parts of the body; or if the subject be naturally lean, and incapable of accumulating fat, the superfluity must be got rid of, and the natural emunctories, the sebaceous follicles of the skin, and the liver, then become disordered; hence appear acne and other follicular diseases of the skin, and various bilious disorders. These results are the most readily produced in sedentary persons, in whom the exercise of the lungs is insufficient to consume the superfluous fat. On the contrary, those who use active exercise can often take considerable quantities of fat with impunity, and sometimes with advantage. For similar reasons, oily food is better borne in cold than in hot climates and seasons: thus, as Liebig has pointed out, the Laplander relishes train oil, which serves to sustain the warmth of his body; whilst the Italian in a sunny climate prefers the less combustible food, maccaroni and fruit, which nourish without heating. The Esquimaux surprise travellers by the enormous quantities of blubber that they can consume; but the Indian is easily satisfied with rice and other light farinaceous vegetables.

* L'Union Médicale, 1850.

The *quality* of oily matter in the food is an important element in its morbific effects; such substances as are most prone to chemical change, or to become solid, are more likely to disagree than others. Thus stale or tainted butter or fats, and rancid oils, are peculiarly offensive to the digestive organs, both on account of the production of injurious acids (butyric and oleic), and because their thickness renders them incapable of the minute division necessary for their absorption and appropriation by the nutritive process. On the other hand, cream, fresh butter, mild fat, and sweet salad oil, agree well and nourish, especially when intimately blended with farinaccous or succulent vegetable matters: and the cod-liver oil, when fresh and free from rancidity, is borne by the weakest stomachs. It is possible that the easy digestibility of certain fats is partly due to the facility with which they form emulsions with the pancreatic and other secretions of the alimentary canal. Thus cod-liver oil and the fat of bacon are among those most easily borne on the stomach, and I am informed by Dr. Lyon Playfair that these both possess the important property of saponifying with the alkaline carbonates, whereas other oils unite only with caustic alkalies.

Amylaceous or *starchy* foods, such as arrowroot, sago, tapioca, and many kindred farinaceous preparations, although isomeric (i. e. consisting of the same elements) with *saccharine* matter, are not quite similar in their physiological effects. Like it, they probably supply a fuel for the process of respiration, rather than sustain the body by nourishing the textures, and so save them from the consuming influence of the oxygen absorbed through the lungs; and if taken in *excess*, they may either lead to the formation of fat, (§ 59,) which is deposited in the textures, or passing into fermentation, they may give origin to acetic, lactic, and oxalic acids, and other matters of an injurious kind; this latter effect occurs more often with saccharine than with amylaceous food. On the alimentary canal too their effects in some degree differ, excess of amylaceous food impairs the action of the intestines and the secretion of the liver, whereas sweet things often relax the bowels and cause a redundancy of bile. These different effects of saccharine food are probably connected with its occasionally containing, or forming, vegetable acids, which irritate the alimentary canal, and which may thence cause dyspepsia, diarrhœa, diabetes, rheumatism, oxaluria, and other disorders of the same class.

Amylaceous and saccharine matters being the mildest materials of food, serve to dilute the stronger articles fibrin and oil, and to render them both more palatable and more digestible; when, therefore, the former are *deficient*, the latter are more apt to disagree, and to fail to nourish. In common with other vegetable principles, such as gum, vegetable jelly, extractive, &c., they also contain alkalies combined with vegetable acids, compounds which are decomposable in persons of strong digestion, the alkali then becoming useful in counteracting the acidity which results from the processes of transformation continually proceeding in the body. On this account fruits, and other vegetables, assist in neutralising and eliminating lithic acid, and in preventing the occurrence of gout and gravel. This view is in accordance with the statements of Prout, Liebig, and Wohler; but I believe it only applies to the case of persons whose digestion is strong; for where this is weak, I find that vegetable acids and fruit commonly increase the acidity of the urine, and are therefore injurious:* whether they do this by passing unaltered through the circulation, or by irritating the primæ viæ, and thus leading to an unusual development of hydrochloric and other unchangeable acids, I cannot say, but the latter course would appear to be the most probable. But there is some reason to suppose that vegetable acids have an influence on the blood before or while they undergo the combustive process; for whether alone or in combination with an alkali, they certainly exercise an operation on the body more cooling and antiphlogistic than can result from the alkalies which they contain. Thus subacid fruits and drinks are found refreshing and really cooling in fevers; and lemon-juice even in large quantities is now generally acknowledged to be powerfully antiphlogistic, especially in rheumatic and gouty inflammation. That this property depends on an eliminating power of the vegetable acids and of their salts is possible, but it may be connected with some direct chemical action by which the materies morbi in the blood is decomposed and thus deprived of its irritating influence.

61. The selection and combination of articles suitable for food would be a difficult task, requiring much scientific knowledge and calculation, were it not that Nature has supplied us with a trustworthy guide, which happily points out the varied wants of the

* This has been confirmed by Dr. Bence Jones, who found that large doses of tartaric acid render the urine more acid than usual.—*Phil. Trans.* 1849.

system in changes of season and diversities of circumstance. The appetite and taste generally instruct us pretty safely as to what are the best proportions in which the different kinds of food should be mixed; but they must not be perverted and pampered by condiments and refined modes of cooking. These expedients coax and deceive the appetite and taste; and if these guardians of the nutritive department are cheated, it is no wonder that the department itself becomes deranged.

62. (*c.*) Aliment may be *excessive* or *deficient* in *quantity*. Sometimes the appetite is inordinate; more frequently it is stimulated and tempted by luxuries; in either case, *more food* is apt to be taken than the expenditure of the system requires. If the digestive organs fail to dispose of this, they become distended, irritated, and otherwise disordered by the undigested part, and the various symptoms of indigestion appear, or perhaps oppressed breathing, palpitation, congestive and convulsive attacks, gastritis, enteritis, colic or diarrhœa. If the digestive organs are strong, and digest the excess of food, they send too much chyle into the blood, which then over-distends the vessels, and deranges the function of assimilation; hence may result plethora, apoplexy, gout, gravel, or some congestive hæmorrhage or inflammatory disorder, to which the individual may have been predisposed (§ 14). Such evil consequences of repletion ensue the more readily in sedentary persons, in whom the waste of the body is small, and the excretions are scanty.

63. *Defective* nourishment excites various disorders. In the extreme case of absolute privation of food the cravings of hunger alternate with nausea, and a sense of sinking: then follow extreme depression, transient fever, delirium, general disorder of both body and mind, increasing feebleness, and inability to maintain animal heat. It is a curious fact, that in this state the stomach sometimes becomes inflamed; probably from the irritating action of its own secretion on the unrelieved vessels. Even in the slighter degrees of abstinence, enjoined by the physician in the treatment of disease, symptoms of vascular and nervous irritation often arise in the midst of general weakness. By many practitioners of the Broussaian school, these symptoms are erroneously taken to be indications for greater rigidity in the antiphlogistic plan, whereas a judicious and cautious return to a nourishing diet is really required, and will prove the best cure.

Deficiency of food ultimately causes general weakness of the functions and wasting of all the textures, but least of those of the nervous system. The blood becomes thin and easily extravasated; the gums spongy and bleeding; fat disappears; the muscles get thin and flabby; the legs become œdematous; diarrhœa often occurs; ulcers appear in the cornea, and other parts which are the least vascular; and a state of scurvy, or cachexy, is induced, from which an improved diet may now fail to restore; for the powers of digestion and assimilation sink with the other functions, and it is only by very gentle and careful management that they can be reinstated when very far gone. Another result of the general depression caused by inanition is the impairment of the action of the excretory glands, in consequence of which effete and decayed matters which ought to be thrown out of the system are retained, and produce fœtid breath and offensive effluvia, as observed in persons who fast long or are ill fed. Doubtless, too, the lowered vitality of the tissues then renders them little able to resist the tendency to decomposition, and hence there is ready decay and interstitial absorption. Chossat found that in animals gradually starved to death the temperature progressively declined, so that unless it were maintained artificially, the animals seemed to die of cold. All the textures, even the bones, sustained great loss of weight; but the substance of the nervous centres wasted far less than that of any other organs. This fact I should be inclined to attribute to the peculiar condition of the blood-vessels supplying these centres, which enables them to monopolize the little blood remaining; in this we find a ready interpretation of the predominance of nervous symptoms in persons suffering from inanition. (See Anæmia.) In less extreme cases, poor living may excite scrofulous and tuberculous disease, and other kindred forms of degeneration of organs. The bad influence of poor living is much more expressed in those who are confined in close habitations, such as prisons, poor-houses, the cabins of ships, and besieged towns, than in those who are at large (§ 22): and it is under such circumstances that the insalubrity of some kinds of food, however nutritious in general, becomes apparent. Thus even bread, with meat, or broth, will not preclude the occurrence of scurvy; but a sufficient addition of fresh vegetables, even if they be only potatoes, prevents this disease from appearing.—(Dr.

Baly, Med. Gaz., Feb. 1843.) It has been observed that pestilential diseases of the most destructive kinds ensue after a period of famine. It is the ill-fed of the population that mainly succumb to epidemic, endemic, and infectious disorders. Dr. Carpenter well suggests that this may be at once explained, when it is remembered that in the body during starvation there is, not merely that general depression of vital powers which may be a predisposition to almost any kind of malady, and pre-eminently to such as are of a zymotic nature,—but also the presence in the blood of an unusual quantity of disintegrating matter, which forms the most favourable nidus for the reception and reproduction of morbific poisons.—(Principles of Human Physiology, 4th Edit., 1853, p. 397.)

64. (4.) *Excessive bodily exertion* is a common exciting cause of disease. General muscular efforts, as in running, walking up hill, rowing, &c., hurry the movement of the blood back to the heart, and resist its distribution through the arteries to such an extent that the heart, the lungs, the brain, and other organs, have an unusual pressure upon them (§ 51). Disease is then readily induced, especially in persons little accustomed to this kind of exercise (24).

The heart, when excited to inordinate action, is often strained and distended, and its function, or even its structure, as well as that of the great vessels, may be impaired in consequence. This is especially apt to happen if there be anything already wrong in the structure of the organ, its valves or vessels; and independently of actual disease there are naturally very various degrees of perfection and strength in these parts.

The brain is particularly liable to suffer from violent exertion, especially if joined with a stooping or constrained posture; for its vessels are not, like those of the limbs and trunk, supported by muscular pressure, the excited heart on this account sends its blood into them with more force. Hence confusion of the senses, giddiness, noise in the ears, deafness, defective vision, convulsions, palsy, and apoplexy, are sometimes brought on by violent exertion.

The lungs too are apt to suffer; for the blood being returned to them faster than they can arterialise it, they become greatly

congested;* cough, dyspnœa, hæmoptysis, or inflammation of the lungs, ensue in this way: the texture of the lungs sometimes also sustains injury in consequence of the violent strain to which it is subjected by the increased exertions made in sustaining the breathing, and temporary emphysema is produced.

Other internal organs are sometimes disordered by the blood thrown into, or retained in, their vessels by the pressure of external muscular action. Derangement of the liver, hæmatemesis, hæmorrhoids, and hæmaturia, have been brought on by such means. The sharp pains or stitches felt in the sides or abdomen on running fast are commonly supposed to be in the liver or spleen: but more probably they are spasms of the intestines—temporary colic,—produced by irregular pressure on them, when their sensibility is raised in consequence of an undue quantity of blood being thrown into them.

Some kinds of muscular exertion peculiarly affect certain organs. Thus loud reading, or speaking, or blowing wind instruments, especially tries the organs of respiration and voice, and may cause hæmorrhage, inflammation, and various diseases of these structures. Excessive or rough riding or leaping may injuriously affect the kidneys and organs of generation. Straining to lift a heavy weight, or at stool, or in any continued effort, which implies holding the breath, endangers the structure of the vessels of the chest and brain, on which there is no equally counteracting muscular pressure exerted at the time.

Long continued bodily exertion may also cause disease by its exhausting effects. In extreme degrees this exhaustion may amount to syncope, and even death: short of this, it may cause great weakness of the muscles and of the heart, with corresponding depression of other functions, congestion of the viscera, and defective assimilation and excretion: hence arises the low typhoid, or adynamic fever, which sometimes follows prolonged fatigue. In these cases the chief disorder must be considered to be in the blood, which becomes loaded with the decaying matters that result from the disintegration of the muscular and other tissues, and

* Some of the most severe cases of pneumonia that I have ever had to treat have occurred in boys at public schools after violent and long sustained exertion at football, and other athletic games. These cases all closely resembled each other, being eminently congestive, and accompanied by much depression in the early stage, and generally affecting both lungs; yet in spite of the formidable character and extent of the disease in these cases, they have in almost every instance recovered.

which takes place more rapidly than the antagonistic processes of elimination and reparation. In slighter cases of great fatigue there are giddiness, faintness, nausea, loss of appetite, indigestion, costiveness, amenorrhœa, and other varieties of injured function. When muscular exercise is carried on so long, or to such a degree, as to impair the organic functions, it thereby induces disorder in them in addition to the weakness, prostration, and actual suffering in the animal functions. A serious part of such disturbance is the sleeplessness which, in extreme fatigue, brings the patient into a state nearly resembling delirium tremens. This, as we have already mentioned when speaking of predisposing causes (§ 23), is mainly due to the state of the respiration, which being insufficiently maintained by the weakened spinal function, is aided by continued voluntary efforts, manifested in the frequent sighing that takes place. In these conditions diffusible stimulants are the best hypnotics.

65. The opposite extreme, *want of exercise*, is capable of exciting as well as of predisposing to disease (§ 24). Thus internal congestions, deficient and disordered secretions, general plethora, over nourishment of adipose texture, and wasting of muscles, besides various evil consequences of these morbid conditions, may result from this cause when in prolonged operation. If combined with some of the other disturbing influences noticed in this section, it is a still more ready and common cause of mischief. Some organs suffer more particularly from a sedentary mode of life; for example, the liver, in consequence of the increased task of decarbonisation of the blood, which deficient respiratory exercise throws on it:* the brain, from its direct and free communication with the centre of the circulation, which exposes it to an accumulation of blood when the distant circulation fails: hence bilious disorders, dyspepsia, hæmorrhoids, headache, and giddiness, &c.

66. (5.) *Excessive mental emotion or exertion, and acute sensation*, are common causes of disease. Closely knit together as the mind and body are, it is not surprising that they should ever be ready to affect each other, and that when the bodily impression is strong, the mental affection should be found to be not slight nor

* When there is more hydro-carbonaceous matter in the blood than can be burned off through the lungs, it is saponified by the liver, and thrown out as bile through the intestines, although in normal states the bile itself is burned away by the respiration.

transient. The heart suffers most remarkably in this way. Thus a sudden shock, whether of grief, surprise, fear, or even joy, may cause fainting, (partial suspension of the action of the heart): nay, even death has ensued; and the expressions "frightened to death," and "killed with joy," are not always mere figures of speech. Sudden acute pain often causes fainting. Palpitation and irregular action of the heart are very common effects of emotion. The pallor of the face, and coldness of the extremities and surface, that result from strong mental disturbance are indications of the manner in which the circulation is deranged under such influences, and these are almost always attended with a corresponding amount of internal congestions, leading to disturbance of the functions of various organs, manifested in spasms, hæmorrhages, fluxes, and other like affections.

Other organs also suffer under strong moral impressions. Spasmodic asthma, and spasmodic affections of the throat and stomach, are sometimes thus induced. Apoplexy, palsy, inflammation of the brain, chorea, epilepsy, catalepsy, and insanity, have been caused by excessive anger, terror, surprise, and joy.

Mental emotions commonly affect the secreting organs, and especially influence the functions of the alimentary canal. A piece of very bad news takes away appetite, or impairs digestion. Fright or anxiety often loosens the bowels, or brings on a bilious attack, or jaundice. The uterine periodic function is remarkably subject to the influence of moral emotions, and many of its disorders may often be traced to this source. The secretion of the breasts is well known to be easily affected by emotion; it is increased by the pleasurable feeling of maternal fondness, and diminished by anxiety, distress, or even joyous excitement, and rendered depraved so that it disagrees with the infant when the mother is suddenly shocked. There have been cases in which under such circumstances the milk has seemed to act even as a positive poison to the child.

The less vivid emotions of the mind, and over-exertion of its faculties, are also sometimes exciting causes of disease. Long-continued depression or anxiety often induces dyspepsia, costiveness, or diarrhœa, asthma, and functional disorders of the heart, liver, and kidney, menorrhagia, and dysmenorrhœa; and structural diseases of the same parts occasionally follow these functional affections. In a large proportion of the cases of degenerative disease of

the kidneys and heart, that have fallen under my notice, the most obvious exciting cause of the mischief has been extreme anxiety, or long-continued mental exertion. There is generally an outward sign of the change manifested in the *arcus* or *circulus senilis* of the eye; this almost always indicates premature age brought on by the wear and tear of excessive mental anxiety or labour, or by "fast living." The influence of mental anxiety and exertion on the function of nutrition is proverbially illustrated by the expression "worn to a shadow;" and the decaying process may be observed in the large amount of urea, lithates, phosphates, and other results of animal decomposition contained in the urine under these circumstances, actually constituting a form of diabetes ureosus, or azoturia. Over-exertion of the faculties, or excitement of the passions of the mind, tells chiefly on the mind and the nervous system. In this way often arise congestions of the brain and exhaustion of nervous power, giddiness, stupor, headache, dull and disordered sensation, and even apoplexy and palsy. Or the disorder may be inflammatory, with symptoms of irregular excitement, nervousness, delirium, tremor, convulsion, partial paralysis, &c. Sometimes the effects of excessive mental exertion or moral emotion are only apparent in mental phenomena, the powers of the mind being so injured or disordered that various forms of insanity are produced. When we consider the variety and amount of employment and excitement (food and condiment, so to speak) that pass into the minds of persons in the busy and worrying scenes of civilized life, it is not extraordinary that its functions, as well as the digestion, or any other vital action, should occasionally get deranged.

67. (6.) *Excessive evacuation* or *loss* either of blood or of some secretion, has been already noticed (§ 28) as one of the causes of debility, which then predisposes to disease; but if the loss be great or sudden, it may produce immediate disease itself. A certain fulness of the heart and blood-vessels is required for their healthy action, as well as for the support of all the organs which they supply. If a moderate quantity of blood be suddenly withdrawn, or a large quantity less suddenly, the heart's action is impaired, rendered irregular, and perhaps interrupted, and the brain not receiving a sufficient current for the maintenance of its functions, fainting may follow, with loss of consciousness, accom-

panied, or succeeded, by palpitation, delirium, convulsion, or even death. The sudden impression in these cases is more marked on the brain than on the heart; for the same effects may be induced by the loss of a much smaller quantity of blood in an erect or sitting, than in a horizontal posture. Similar results have been found to ensue in consequence of the sudden removal of pressure from the vessels in any considerable part of the body, as by the discharge of the fluid of ascites, or by enclosing a limb in an exhausting tube. (Dr. Arnott.) Lower mentions a case of extensive varix (enlargement) of the veins of the lower extremities, in which the patient could not stand without fainting, until the legs were bandaged. In these cases, much of the blood, although not removed from the system, gravitates into the enlarged vessels, and becomes unavailable for the general circulation. The fainting which occurs is called *cerebral syncope*, because the functions of the brain are suspended; consciousness is lost before the heart's action is interrupted; but the disorder of the brain reacts on the heart, and thus adds another cause of impairment of its own action. This is Dr. Alison's explanation. On the other hand, if the hæmorrhage is gradual, and the posture horizontal, other functions fail before the consciousness is lost — the chief symptoms being "feebleness of muscular action, paleness and collapse of the countenance, coldness, beginning at the extremities, cold sweat, commencing on the face, the pulse imperceptible," and the heart's action failing. The true nature of these effects, and of the reaction and nervous symptoms by which they are often followed, will be considered hereafter in connexion with the subject of anæmia.

Not only blood-letting and hæmorrhages, but other evacuations, such as purging, sweating, vomiting, and excessive catamenial and seminal discharges, are capable of producing syncope and general debility. The depression and faintness induced by these, although less prompt, are often more permanent than are those from blood-letting; for such evacuations imply, not only reduction in the mass of blood, but also exhaustion of the vital energies of the secretions and actions concerned in producing them.

The diseases gradually induced by these several causes of evacuation are seldom of a simple kind. General weakness of the muscles and functions is a common result; but this is often complicated with symptoms of partial reaction, palpitation, spasms, noises in the head, spectral images, pains in different parts, some-

times very acute, but seldom long fixed, partial paralysis, and a defective and disordered state of the excretions.

68. (7.) *Deficient evacuation* of excrementitious matter, whether habitual or accidental, is a very fertile source of disease. Its morbific influence is however considerably diversified. Sometimes it causes disease by the positively noxious influence of matter retained in the system; this is the case when it is the excretion of urine and fæces that is concerned; at other times, by promoting fulness of the vessels, and thus leading to the various disorders commonly consequent upon this. To the latter category belongs the sudden suppression of hæmorrhages, or other discharges which have become habitual, whether they be milk, mucus, serum or pus. Deficient excretion from the bowels is a very frequent cause of derangement in the health, manifesting itself by an entire train of symptoms, such as furred tongue, foul breath, depraved appetite, headache, general torpor and weakness, loaded urine, offensive perspiration and eruptions on the skin.

The matter of alvine and renal excretions is essentially pernicious, and cannot be long retained even in their natural repositories without causing mischief. Fæculent matter, when it has reached the large intestine, is still acted on by the absorbents, which take up its more fluid parts, and with them, if long retained, fœtid matter, which ought to be excreted. The solid residue becomes hard and scybalous, and may remain lodged in the cells of the colon, a cause of irritation, distension, and obstruction (§ 51). Sometimes the system then suffers before the intestine itself; but sooner or later this part becomes irritated, colic, diarrhœa, and inflammation ensue; and in some instances, where efficient remedies are neglected, even ulceration and other structural changes take place, before the offending matter is dislodged.

The retention of urine has yet more serious effects. Besides mechanical distension, irritation, inflammation, and rupture of the bladder, which may follow from the constantly accumulating secretion (§ 51), the fluid is partially reabsorbed, giving a urinous smell to the breath and perspiration, and sometimes causing typhoid symptoms, and in extreme cases proving fatal, with the presence of delirium, or convulsions, and coma; effusions of serum, containing urea, are then found in the brain, chest, and other parts. These effects are more commonly produced by suppression than by mere

retention; but, in fact, suppression often follows retention: retained urine is prone to decomposition (§ 53); highly irritating and offensive matters are formed in it, which cause injury to the bladder, rapidly extending up the ureters to the kidneys, whose functions then become impaired or destroyed. In some cases of the early stage of the severest form of Bright's disease, in which the urine was very scantily secreted and highly albuminous, I have seen typhoid symptoms of the worst character, accompanied by a breaking up and partial solution of the colouring matter of the blood, with the appearance of pus globules in it; in two instances there was effusion of a bloody purulent fluid into the joints a day or two before death: these results will be further noticed when treating of defective excretion and purification of the blood as an element of disease. Checked perspiration is a frequent and fully admitted cause of disease, commonly of a febrile, rheumatic or inflammatory nature: the sudden suppression of a fœtid sweat in the feet, axillæ, and other parts, has sometimes been followed by such serious disturbance of the health, as plainly to indicate that the matter thus retained must be of a highly noxious kind.

The above illustrations relate to extreme cases; but the attentive observer will find that the same causes, insufficient secretion, and insufficient evacuation of excrementitious matters, in slighter degrees, are among the commonest sources of disorder; and it is by effecting a restoration of the proper state of these functions, that the almost universal domestic remedies, as well as the common pills and draughts of the surgery, prove efficacious in preventing as well as in removing disease. Many occasions will occur for the illustration of these facts.

Numberless maladies arise from suppression or irregularity of the catamenial discharge, which appears to be blood in a highly carbonised state; it is hence manifest why its excretion gives relief. Diseases are not unfrequently excited, or rendered active, at the period of its total cessation. Something of the same kind may be said of the secretion of milk. The disorders which are thus produced are at first connected with local or general plethora; but eventually the quality of the blood becomes depraved in consequence of the accumulation of these excrementitious matters.

69. An artificial discharge or diseased secretion, such as proceeds from a seton or issue, or from an ulcer or diseased membrane, or an unnaturally profuse flow of an ordinary secretion—such as loose-

ness of the bowels, if so long established as to have become habitual —cannot be suddenly suppressed without great risk of exciting disease. In the case of habitual puriform or sanious discharges from setons, issues, and old sores, sudden suppression has sometimes given rise to the most formidable symptoms, shewing plainly that a noxious matter had been thrown back upon the system : the fear of the occurrence of such accidental suppression, which cannot be always prevented, deters me from frequently employing these artificial drains in the treatment of disease.* Habitual hæmorrhages, as from the nose or rectum, and the practice of periodical bloodletting, cannot be abruptly stopped with safety. The maladies which are likely to ensue vary according to the predisposition ; but generally they are connected with local or general vascular fulness, or take the form of some disorder of secretion, or of the nervous system, directly depending upon disturbances in the circulation. Congestion of the brain, apoplexy, congestion of the liver, various hæmorrhages and inflammations, gout, epilepsy, palsy, hysteria, hypochondriasis, and mania, may be specified by way of example.

The suppression, or too rapid removal, of some cutaneous eruptions may be looked upon as belonging to this class. The diseases so excited are sometimes inflammatory or profluvial, as gout, rheumatism, and diarrhœa ; sometimes of a more nervous nature, as chorea, epilepsy, asthma, dyspepsia, and hysteria.

70. (8.) *Defective cleanliness, ventilation, and drainage.*— These influences might be expected to be very pernicious from what has been premised above ; there are few kinds of filth more offensive, few mephitic gases more foul, and few descriptions of offal more abominable, than those that are excreted from the animal

* A patient who had been under my care with organic disease of the heart (hypertrophy and mitral valve lesion) was recommended by another physician to have a seton inserted in the left side. Some months subsequently I was summoned to him in consequence of his having a severe attack of pleuro-pneumonia, of the right side, which supervened upon a sudden and altogether unaccountable cessation of the discharge from the seton. The affection proved intractable, being accompanied by an unusual degree of constitutional irritation and depression, and terminated fatally. Collections of pus were found in the right lung, and between layers of lymph effused on the pleura. A gentleman with chronic phthisis was in the habit of using croton oil freely as a counter-irritant upon his chest. Trusting in an imaginary security from this, he upon one occasion exposed himself to cold whilst a full pustular eruption was present upon his skin. The next night he was attacked with rigors, followed by fever and orthopnœa, and sank in three days under suppurative bronchitis.

body itself. If, therefore, as we have seen, such matters are so very injurious, when not sufficiently eliminated out of the body, it is not surprising that they continue to be noxious, and may become active causes of disease even after they have been evacuated, if proper means be not taken to remove them out of the way. The need of self-purification might be inferred from the instinctive habits of many animals and birds, which take great pains to cleanse themselves and their young, and in many instances carefully remove excrements from their nests and habitations. Even plants are supposed by some botanists, to exhibit a like provision to preserve themselves against self-poisoning, by the constant spreading of their roots into fresh soil, that is not contaminated by their own excreted matter. Yet, with strange disregard of these preservative instincts, and indolent neglect of the plainest dictates of reason, human beings continually expose themselves to the evil influence of their own accumulated filth, until disease is engendered, and aggravated into pestilence, and the usual rate of mortality among the people is doubled or tripled.*

Although the three particulars, neglect of cleanliness, imperfect ventilation, and defective drainage, operate much in the same way, and very commonly combine their influence, yet it will be useful to consider briefly the mode in which each excites disease, with a view to the consideration of remedial measures.

71. (*a*) *Filth accumulated on the surface of the body*, consists of the thickened residue of perspiration, mingled with such extraneous dust or dirt as may chance to reach the skin. The sweat is peculiarly rank and offensive in some persons, especially when accumulated during much muscular exertion; and in some parts, such as the axillæ, the perinæum, and between the toes, it is combined with an odorous principle, whose disagreeable character would almost seem to have been intended by nature to suggest the necessity of

* Every practitioner of experience has to encounter manifold proofs of the potency of these causes in generating and aggravating disease; the profession and public possess a valuable collection of testimony on this point, in the following official reports:—

Report from the Poor Law Commissioners on the Sanitary Condition of the Labouring Classes. 1842. By E. Chadwick, Esq.

Supplementary Report of the Practice of Interment in Towns. 1843. By E. Chadwick, Esq.

Reports of Commissioners on the State of Large Towns and Populous Districts. 4 vols. 1844.—1845.

Reports of Dr. Neil Arnott and Mr. Thomas Page on the Prevalence of Disease at Croydon. 1853.

frequent ablutions; yet how many, and these not confined to the lowest ranks, are "content to live in dirt and stink;" and often eventually pay the penalty of their filthiness in various cutaneous diseases thereby induced! The accumulation of filth on the skin also favours the propagation of vermin, and of contagious diseases, especially the itch, from which few of the "mighty unwashed" are totally free. The same influence also impedes free perspiration, and thus leads to the production of rheumatism and diseases of the urinary, and other organs, which sympathise with the skin. Neglect of cleanliness in clothes and dwellings, even when not immediately injurious through the direct contact of filth with the skin, may yet become hurtful by contaminating the air.

72. (*b*) *Defective Ventilation,* or insufficient change of the air of dwellings, might be considered to readily suggest its proper remedy by the feeling of suffocation that is induced; but it is not always the deficiency of oxygen, or excess of carbonic acid, that is equal to the production of a stifling sensation, which does most harm: it is rather the scanty supply of fresh air which stints the vital processes without suddenly disturbing them; and the gradual accumulation of foul effluvia which slowly poisons without exciting alarm. Persons are gradually brought to endure, without distress, the impure air of a close room, although to any one entering from the open atmosphere it may seem quite suffocating. Thus in the habitations of the poor, especially in densely populated towns, it is not rare to find ten or fifteen persons crowded together in one small room, without any other supply of air than that which comes through chinks of the floor or window, or that which enters when the door is occasionally opened. Amongst the lower classes in towns, the dread of cold prevails much more than the desire for fresh air; and except in the height of summer, the solitary window is rarely opened; and during the night, when the greatest number are collected together, every external opening is carefully closed. During the winter the same plan is pursued; but, if there be then any fire in the hearth, a greater amount of ventilation is perforce ensured.

The habitual want of pure air especially exerts an unfavourable influence on the state of the blood, and on the functions of circulation and nutrition, causing pallidity of the surface, and imperfect development of the corpuscles and plasma, which, then, instead of

contributing to the nourishment of the textures, degenerate into scrofulous or tuberculous matter, whose deposition in the internal organs or glands is further favoured by the weakness of the circulation. Exercise does, in some degree, counteract this effect of impure air: thus Dr. Guy found that in the close workshops of a printing establishment, 44 per cent. of the compositors, whose employment requires no exertion, fall victims to phthisis, while not more than 31½ per cent. of the pressmen, who, while breathing the same air, use active bodily efforts, do the same. This difference is quite intelligible when it is remembered that active exercise tends to remove congestions, and to promote excretion, by increasing and extending the force of the circulation, and to excite the respiratory function, so purifying the condition of the blood. Similar exercise in pure air has, however, much more salutary effect; for the deaths from phthisis among out-door labourers do not exceed 25 per cent.

Insufficient ventilation is by no means confined to the habitations of the poor. In modern days, when the construction of houses is more complete than it was in olden times, there are no longer the latticed casements, chinky floors, ill-fitted doors, and above all, the roaring pile of burning wood on the spacious hearth, that supplied abundant ventilation to the houses of our forefathers: now, in proportion as houses are "well-built," every crevice is so thoroughly stopped, that our rooms are well nigh air-tight, and when doors and windows are closed, the occupants are consequently enclosed in an atmosphere, which is more injurious in proportion to the number assembled. Add to this the vitiating effect of artificial lights, and fires, whose smoke does not perfectly escape for want of sufficient draught, and it will be very apparent why it is that modern houses often comprise conditions eminently calculated to ensure the presence of this cause of disease. In public offices, schools, hospitals, churches, chapels, theatres, and other places where great numbers collect together, the mischief is still more fully in operation; and it is quite certain that not only is the public health much injured in this way, but that much of the useful or agreeable objects of such assemblies is also lost in consequence of the discomfort caused.

The ill effects of deficient ventilation are increased by heat and moisture; the former operates, not only by increasing the animal exhalations, but also by rarefying the air, and thus reducing the amount of oxygen in any given bulk: moisture probably acts by

lessening the difference between the air respired, and that contained in the lungs, which promotes that diffusion, or interpenetration of gases whereby the access of oxygen to the air cells is insured. For be it remembered, the air taken in at each inspiration, is not enough to reach far in the pulmonary tubes; its further transfer into the air-cells is mainly accomplished by the law of diffusion of gases, which operates powerfully in proportion to the dissimilarity between the gases.

Gases or vapours of a positively noxious quality are engendered, during certain occupations, which augment the evils of deficient ventilation. Such is the case in many chemical works, slaughter-houses, and dissecting-rooms, soap, glue, and catgut manufactories, and in employments in which materials are used containing mercury, white lead, and arsenic (§ 53). The deleterious operation of effluvia arising under these circumstances may stop short of a directly poisonous effect, and yet by adding to the unwholesomeness of the atmosphere, it may gradually undermine the health: it is best counteracted by more efficient ventilation.

73. (*c.*) *Defective drainage* necessarily produces an active state of the influences above specified, namely, filth and foul air; but it also implies circumstances that may exceed these in pernicious operation. The soil, which drains from habitations, contains in addition to excrement, dirty water, the washings and remnants of animal and vegetable matters used as food, and other offal; all these are mixed together and stagnant in the corrupting slough that is retained in cesspools and privies, or that is carried into sewers. The stench which exhales when these receptacles are opened, gives some idea of the deleterious influence they originate, and the fearfully poisonous nature of the emitted gases is often proved by the sudden faintness and sickness, nausea, vomiting, and diarrhœa, which attack persons engaged in emptying them. Instances have occurred of individuals being speedily asphyxiated by the gases of cesspools; and others are on record in which, although the result was not immediately fatal, congestive or typhoid pneumonia ensued, which passed into gangrene in the first stage. (Chomel). The precise nature of the gases evolved in these circumstances has not been fully ascertained; but they obviously contain much sulphuretted and carburetted hydrogen; these, however, although known to be highly noxious, do not comprise the

most dangerous ingredients of these offensive effluvia. It is no wonder then, that every ill-drained house has a Pandora's box, ready to pour forth its evils whenever occasion offers; and always oozing them out in degrees sufficient for the impairment of the health of the inhabitants, and the gradual excitement of cachectic and other chronic diseases. Hence it is, as appears in the several sanitary reports before cited, that the mortality rises in a remarkable proportion in all those districts of towns where sewerage is absent or inefficient. The worst nuisance of this description is the cess-pool without a drain from it; unemptied for months or years, and often imperfectly covered, it continually poisons both air and water; and typhoid fever, diarrhœa, cholera, dysentery, dyspepsia, inappetency, general weakness, and malnutrition are results of its pestiferous operation acting in different degrees. Scarcely less injurious, and even more insidious in its operation, because the effluvium is less offensive, is the untrapped drain often found in connection with the sewers of large towns. This cause of disease exists extensively in London, not only in the street drains, which are always open and emitting the gases of the sewer, the bad odour of which is perceptible during certain winds, but also in the drains of houses which are either intentionally or negligently left open, or are not kept air-tight by the presence of water in the traps. Nothing is more common than to perceive the peculiar smell of the drain on entering a house, and in many instances I have found that this has proceeded from the trap being left open, or from the water being dried away, the trap being therefore inoperative, although requiring only the simplest expedient to remedy the evil. When a single trap is open in a house, especially in the winter when doors and windows are closed, and the supply of fresh air is inadequate for the fires in the house, the foul air is drawn up from the sewer in a strong current, and quickly pervades the house from bottom to top, carrying everywhere its pernicious influence. It is surprising how ignorant servants and their employers, and even professional men, seem to be on this point, although one which so immediately concerns their health and comfort: I have visited in many houses where illness, or impeded convalescence, low nervous fevers, bowel complaints, influenza, neuralgia, and headaches, besides other ailments, have been induced by this cause. In some instances the leakage is a consequence of the inroads of rats, or the displacement of the brickwork of the drains. It may

be useful to state, that besides by the smell, which is not obvious to every one, the effluvia of drains may be detected by the darkening of white paint, and the speedy spoiling of meat kept in the basement story of the house.

74. (9.) Of all the exciting causes of disease, there are none more common than *extremes or sudden transitions of temperature.* Both heat and cold, however, operate on the living body in different modes, and cause disease in a variety of ways.

Extreme heat and extreme cold are directly destructive to life. Heat above 180° coagulates the albumen of the blood, and thus obstructs the blood-vessels, and produces other chemical changes of a disorganizing nature (§ 53): a part that has been raised to this temperature, therefore, necessarily dies; it cannot live again. It is true that we occasionally see the application of boiling water at 212°, of boiling oil at 600°, and of red hot iron at 1000°, produce no other effect than violent inflammation and blistering of a part; but that is because these bodies have then been applied for too short a time to do more than violently stimulate the part; time enough is not afforded to raise the part to the decomposing temperature; an instant more, and the part would be killed.

Cold below 32° freezes the water of the fluids; and as it destroys the life of tender plants, so also it often kills parts of animals; but whether by the expansion of the ice injuring the delicate organization, (Sir B. Brodie), or whether from the mere stoppage of the circulation, or from some other cause, is unknown. The destroyed part may be afterwards separated from the living parts by the processes of inflammation and sloughing. From the observations of Dr. James Arnott, it appears, however, that parts of the surface and of limbs may be congealed by the application of a freezing mixture, without any permanent injury to the structure; and he strongly recommends this method of benumbing the part to prevent the pain of surgical operations, as safer than the induction of general insensibility by the inhalation of chloroform. Probably the duration and degree of this artificial congelation fall short of the more serious effects of frost-bite. The method deserves a fuller trial not only for surgical purposes, but also for the sake of its therapeutical influence in the removal of pain and the subduction of inflammation. The power of the body to resist cold, whether generally or locally applied, is apparently connected

such as tearing off or crushing a limb (§ 52). It directly depresses all the functions: the pulse becomes very weak, frequent, and sometimes irregular; the muscular strength is almost annihilated, and consciousness is nearly or quite suspended. In this state, notwithstanding the stimulant power of heat, and the inflammation which it generally excites, patients require stimulants, and they often die in a state of complete collapse, without any rallying or reaction. Extreme cold, also, if applied for some time to the whole body, depresses and paralyzes all its powers, even that of generating heat, and, therefore, of resisting cold. Sir Astley Cooper observed, that on plunging kittens into ice-cold water, the arterial blood did not become venous in the veins; and Chossat found, that when animals were killed by cold, there was arterial blood in the left cavities of the heart. The limbs become benumbed by extreme or continued cold: and hence persons are drowned in cold weather much more speedily than in warm. In degrees of cold, on the other hand, not sufficiently intense to destroy the vital processes, more oxygen is absorbed by the blood, more carbonic acid formed, and more heat generated, these being the means whereby animals are enabled to resist cold. As, however, extreme degrees of cold reduce the vital properties and functions of the body, so it is reasonable to infer that the prolonged application of more moderate cold must also impair them; and this inference is confirmed by the fact that when the body is benumbed by continued cold, the circulation is enfeebled, and the secretions more or less disturbed.

76. Heat, in insufficient intensity to effect the decomposition of organized structure, is directly stimulant. It excites the functions of organs, and when generally applied, may even induce a state of fever. Thus when a person is in a vapour bath, or a hot-air bath, the pulse is quickened, and the whole surface becomes

full, and hot; there are throbbing and pain in the temples, and a feeling of feverish oppression, until a sweat breaks out; this then soon relieves the superficial tension and fulness, and reduces the increased heat. Effects of this kind often ensue from confinement in overheated rooms: and if there be any tendency to local congestion or inflammation, particularly in the head, the excitement may be enough for the production of the mischief. The continued operation of heat enervates, reduces the strength and appetite, and may excite disorder of the liver. Liebig thinks that the oppressed breathing, so often felt in heated rooms, may be ascribed to the smaller amount of oxygen which air rarefied by heat contains; but it is probable that this is not the only cause.

The exposure of a portion of the body to heat, may produce still more disordering effects, if the part overheated be of a nature disposing it to suffer from the excitement. Thus solar or artificial heat, applied to the head, may cause severe headache, apoplexy, or inflammation of the brain. Heat to the spine, as from sitting with the back near a large fire, is very apt to cause sickness and faintness, and, if continued, may induce convulsions. More local inflammations, as of the eye, ear, and portions of the skin, are frequently caused by exposure of the suffering parts to heat. Gout may sometimes be excited in the feet by the application of the same stimulus; this is often done with the design of localising the disorder.

77. Cold, on the other hand, is directly sedative. It contracts tissues and vessels, especially the arteries, and thus at first renders parts pale and shrunk. In persons of feeble circulation, the fingers are sometimes quite bloodless and numb after bathing; the cold having quite closed up the arteries.* But cold also retards the passage of the blood through the capillaries; the viscidity of the liquor sanguinis seems to be increased by it; the corpuscles stick to the sides of the vessels, or move but slowly, and the part soon becomes purple or blue from congestion of blood. This purple

* A similar effect may be watched through the microscope, on applying ice-cold water to the frog's web: the arteries contract to obliteration. This is contrary to the assertion of Poiseuille. (See my Gulstonian Lectures, Med. Gaz., July 16, 1841, p. 639.) It must be remarked, that the primary action of cold on the arteries is strictly stimulant, exciting their vital property of contraction; but its direct operation on textures and organs is sedative, because it impedes the circulation which supports their functions. So, too, it has been found, that when its influence reaches the heart, it paralyses its powers (§ 74).

fall. In some such cases there has been a flow of blood from the nostrils or ears: the stupor has continued for hours after the heat and circulation have been restored; and, in fatal cases, much serous effusion has been found in the brain.* Further observation is needed on these points; but it is most probable that these changes are not the mere result of the congestive influence of cold. In proportion as the blood remains long stagnant other functions are also interrupted, nutrition and secretion in particular; and the arrest of these causes a more serious result than what would follow from the mere occurrence of a temporary congestion. We shall hereafter find reason to conclude that the lowering of the chemical changes in the blood and tissues from the operation of cold, in itself contributes to increase the capillary congestion.

78. Hitherto we have considered the *immediate* operation of cold (§ 74, 77). But its indirect effects are more commonly known: these are, reaction, irritation, inflammation, and their consequences; they are more manifest where the cold has been partially applied, and the strength of the general circulation is not reduced. Thus, after a part has been exposed to severe cold, it becomes the seat of increased flow of blood, so soon as it is restored to warmth, this causes redness, pain, and more heat; and various forms of inflammation may ensue, generally, however, modified by the specific effect which the previous cold has exercised on the vessels and nerves; and also varying with the strength of the general circulation. Thus, chilblain, gangrenous or erysipelatous inflammation, paralysis, and altered sensation are among the indirect effects of cold. As much of the disorder arises in these cases from the violence of the reaction and inflammation, and as this depends on the sudden return of heat and circulation in the part, it becomes an obvious measure of prudence in the treatment of frost-bitten limbs, to retard such return by cold applications. But as

* Kellie, Edinburgh Med. Journal, vol. i. p. 304.

Alison well remarks, this precaution is not needed, where the ative effects of cold have been more general; here warmth and stimulants may be used freely, for there is no fear of an injurious partial reaction.

79. We have hitherto been considering the manner in which cold causes disorder in the parts to which it is applied; but this is not the most general way in which cold excites disease. A person gets his feet wet, stands in a draught of cold air, or, is exposed to cold when insufficiently clothed; he afterwards becomes diseased—not in the feet, or the parts chilled, but in some *internal* part. He gets a sore throat, a "cold in the head" or chest, an inflammation of the lungs, a rheumatism in the limbs, a looseness of the bowels, a catarrh of the bladder, or any other disease to which he may be predisposed (§ 14). Now how does the *external* application of cold cause this internal disease? How is the effect transferred from external to internal parts?

Dr. Alison supposes that the cold operates chiefly on the nerves, and that the sensation which it excites is conveyed by the nerves to the internal organs, where its morbid effects become manifest. But it must be objected to this that the morbific effects of cold are by no means proportioned to the sensation, or nervous impression, which it excites. A person may have his limbs aching and benumbed with general cold; and yet no internal disease results. But if he has been exerting himself, is perspiring, and then gets his feet wet, or is otherwise chilled, and does not continue his exercise, he will be pretty sure to *catch* cold, and to exhibit some one or other of its internal morbid effects, even although he has scarcely been sensible of any impression. It therefore seems more probable, that external cold excites internal disease, by deranging the circulation and condition of the blood, particularly in the capillaries. Cold checks the secretion of the external surface, perspiration; it constricts and obstructs the vessels of the skin (§ 77), and thus throws more blood inwardly, so that internal congestions are produced—these internal congestions impair the functions of the affected organs, especially if they are such as are concerned in excretion (§ 68), and in other ways lay the foundation of disease. This intropulsive effect of cold takes place more readily and to a greater extent, in proportion to the weakness or sluggishness of the capillary circulation. If this be weak naturally (§ 20), there is a constant liability to "take cold." Or if it be weak and relaxed

from previous excitement, during fatigue (§ 23, 24), or during sleep, the same result is apt to follow. Hence persons are most liable to catch cold after being in a hot room, after making exertion, or when asleep. On the other hand, the injurious effect of cold is lessened, or prevented, by a vigorous state of the capillary circulation, whether that vigour be natural, or artificially excited by continued exertion, stimulating drinks, or by febrile excitement (§ 17).

On this view we can understand why the partial, but continued, application of cold, such as occurs from draughts of cold air, wearing damp clothes, and standing on cold stones, should be particularly injurious, even although the sensation of cold excited is not great. Such chilling influences acting long on the same part, completely constrict its vessels, check its secretion and nutrition, injure the balance of the circulation, and by determining a corresponding amount of congestion inwardly, fix it in some part predisposed to disease (§ 14). Nor is it to be overlooked that this derangement of circulation and of secretion and nutrition produces a corresponding change in the condition of the blood; and this change serves to explain why the morbific influence of cold, often cannot be removed until some critical discharge takes place, as by perspiration or urine. It is probably by interrupting or modifying the processes of nutrition and disintegration of textures that cold operates in causing rheumatic pains in muscles and fasciæ exposed to its influence. Thus the decaying material which under ordinary warmth assumes the form of urea, may by the retarding influence of cold be changed only into lithic or lactic acid, and immediately exert that irritating influence on the part which causes the rheumatic pain resulting directly from cold.

When a person has thus taken cold, which he knows by *general* sensations of coldness and weak circulation, rather than by any feelings in the part chilled, powerful measures which tend to restore the balance of the circulation and excite the defective secretions, such as violent exertion, a hot or vapour bath, or stimulant drinks, will often prevent the further progress of disease. The general exposure to a cold atmosphere, if not long continued, is less injurious than a partial application, both because it disturbs the balance of the circulation less, and because also it supplies the lungs with denser air, and therefore with more oxygen; its impression on the nerves of the face and chest also excites more energetic respiratory movements, which maintain the heat and the vigour of

the circulation. Healthy persons rarely take cold when travelling on the top of a coach, or in a perfectly open carriage, but they frequently suffer if in a close carriage with the windows open.

Railway travelling is particularly dangerous in cold weather, on account of the strong current of air caused by the speed. It was not discovered, until abundantly illustrated by numberless cases of catarrh, lumbago, and pleurisy, that more clothing is required even in first-class railway carriages, than in stage coaches, and that there is rarely any need of an open window to secure ventilation.

Damp foggy air seems to act injuriously on the body in a peculiar manner, independently of its mere temperature, irritating in particular the eyes and air passages. Professor Schœnbein considers this effect to be due to the presence of ozone, a principle which he conceives to have the power of producing influenza and catarrh, at the same time that it is capable of destroying malarious and infectious poisons.

80. Susceptibility to the morbid effects of cold is to be diminished by means tending to invigorate the capillary circulation, especially when they are such at the same time as serve to promote that process of reaction which is nature's ordinary method of resisting cold. Now nothing does this more than sudden artificial applications of cold, as by cold bathing or sponging, followed by friction, exercise, heat, or stimulant applications, which promote the reaction (§ 16). The great art in accomplishing these intentions, consists in using the cold in such a manner and degree, and in having the body in such a state before and after the application, that the reaction or glow shall be most fully produced. If the cold be applied too long, or when the body is exhausted by fatigue or exertion, or when it is naturally too weak, the depressing effects of the agent will be continued, there will be little or no reaction, and sensations of languor and chilliness will show that the application has been injurious instead of beneficial. The addition of salt to the water of baths communicates a stimulant property, which promotes reaction, and a similar influence results from the force or shock with which the water is applied. The shock excites frequent deep and forcible respirations through the influence of the nerves; and these accelerated breathings are probably the efficient cause of the process of reaction which follows.

The reaction which follows the judicious use of cold as a therapeutic agent, may prove serviceable, not only in resisting the

further influence of cold, but also by removing congestions and irregularities in the circulation produced by other causes, and by exciting in the capillaries and secernents new actions, which may supersede those of disease. It is thus that the "water cure" of Priessnitz chiefly operates; and although too powerful an agent to be entrusted to unskilled and unscientific hands, it promises to become a valuable addition to the means of combating diseases, particularly of a chronic kind. The excitement and exhilaration sometimes produced by the free application and imbibition of cold water is very remarkable, and in numerous disorders connected with mere loss of tone in the vascular system, may prove very beneficial. But in cases of organic disease, or extreme weakness, the influence of cold water may be very injurious, even though it may seem refreshing and invigorating for the time. I have known many cases in which patients have fancied themselves improving under the treatment, when in fact organic mischief has been rapidly increasing, and flesh and blood have been wasting. The excitement induced by the water almost resembles intoxication, giving a fictitious feeling of strength, in the midst of increasing weakness.

81. In the preceding remarks on cold, it must be understood that the term is applied relatively, not absolutely: cold is not a fixed temperature, or range of temperature; but simply a degree of heat considerably below the temperature of the body. Thus a living body that has been warmed throughout to a heat of 98°, and kept in an excited state by that temperature, would suffer from a draught of air at 70°, which would then feel cold to the body, and produce the physiological and pathological effects of cold. But if the body had not been previously warmed, so that the temperature of most parts of the surface exceeded 85°, or if, being so warmed, the energies of the body had not been exhausted, then air at 70° would feel pleasant, and produce no chill. This is one of many conditions which distinguish vital from physical properties. Physical or chemical properties are invariably affected in a certain way by given temperatures, independent of previous circumstances: but vital properties are variously affected by them in consequence of possessing that power of adaptation, whereby they are enabled to maintain the same states of function in varying external circumstances.

It is for these reasons that atmospheric changes in variable

limates are fertile causes of disease. In this country, on a sudden hange of wind, the temperature often falls 15° or 20° in the ourse of a day, and without any particular exposure the body nay become so chilled in consequence as to suffer to a degree ufficient for the production of disease. Internal congestions ommonly result, but the seat of the congestion varies with the tate of predisposition. After the heat of summer, the organs nost apt to suffer are the liver and the abdominal viscera, because hey have then been exposed to great excitement (§ 25): on the ther hand, in the spring, after the winter cold, the lungs and ir-passages are more prone to derangement (§ 26).

II. NONCOGNIZABLE AGENTS.

We now proceed to notice those causes of disease, whose existence is merely inferred from the fact that disease prevails under certain circumstances, and cannot be explained unless upon the assumption of the existence of certain peculiar agencies, although we cannot prove their existence in any other way (§ 51). These comprise what are termed the *endemic, epidemic,* and *infectious* poisons. In the reports of the Registrar General these poisons are termed *zymotic* (ζύμη, a ferment): the epithet implies an hypothetical explanation, which may perhaps be still deemed open to question; but it is, nevertheless, a very convenient designation for these mysterious morbific influences.

(1.) ENDEMIC POISONS.

82. Persons living in a marshy district are frequently afflicted by a disease called *ague,* which does not attack people inhabiting dry lands. And again, the inhabitants of certain deep valleys are often affected with the swelling in the neck, called bronchocele or goître; while the neighbouring mountaineers are not so affected; and when the inhabitants of the valleys remove their residence to the mountains, they generally lose their liability to the disease. These affections are instances of diseases which may be said to dwell among the residents in particular spots; hence they are called *endemic, in* the people (ἐν δῆμος).

Much doubt still exists regarding the precise source of endemic influence; some persons suppose that it is to be traced to the water, others to emanations from the soil. Intermittent and remit-

tent fevers certainly very commonly originate in marshes, jungles, and rice-grounds, for it has been found that when the wind blows across such tracts of land, the disease appears in persons residing to leeward, but not in those residing to windward; and it has been abundantly proved, that when the marshy spots are drained, ague ceases. From these and similar facts, it has been inferred that the cause of ague is an *effluvium, miasm, malaria,* or bad air; an *aerial poison,* inhaled with the breath, and absorbed from the lungs into the system.

83. The exact nature of marsh malaria has not hitherto been determined. It has never been detected by chemical analysis. Professor Daniel conjectured that the malaria which causes the destructive endemic fevers on the coast of Western Africa, might be sulphuretted hydrogen evolved from the sea water by the decomposing vegetable matter brought down by the rivers; but experiments made in the late unfortunate expedition to the Niger are opposed to this notion. The microscope, rather than chemical analysis, will probably one day throw light on the nature of malaria.

But although the exact nature of marsh malaria is not known, we are acquainted with some of its general properties. It seems to be heavier than air; for persons occupying a ground floor suffer from it more than those living in upper apartments. Water seems to absorb or destroy it; for persons on board ship, or on the side of a lake opposite to the marsh, are not affected; although a favourable wind will convey the pernicious influence to a much greater distance over land. A damp state *of the air,* however, favours its production: good fires in a house afford marked protection to its inmates. It seems to be attracted by trees; for the vicinity of trees is doubly dangerous; whilst places beyond the trees are more free from its effects than others at the same distance which are unsheltered.

84. The chief points known, with regard to the source of malaria, are, that it arises from the operation of the sun's heat on marshy ground, or on the banks or deltas of rivers, especially if devoid of tidal flow, after evaporation has proceeded to some extent; putrefaction of organic matter not being an essential part of the process.* The virulence of the malaria, shown in the severity

* Chisholm and Ferguson, Ed. Med. and Surg. Journal, vol. vi.; Trans. Roy. Soc. Edin., vol. ix.

of the disease excited, and in the number of persons who are affected, seems to bear some proportion to the heat, which has led to its development. Thus the ague of this country, the pernicious intermittent of Italy, and the malignant intermittent of Western Africa and the West Indies, all seem to arise from similar endemic causes, but differ materially in their virulence, being the most formidable where the heat is greatest. A certain amount of moisture is, however, requisite to the effect; a very dry season, which desiccates a marsh, stops the malaria; and the deposit of the evening dew always favours its production (§ 83). Excess of moisture, on the other hand, checks its development, so that a very wet season, as well as a very dry one, may render a marsh less unhealthy (§ 83). But extreme heat does not diminish malaria on the banks of rivers, because portions of these are never dry. The low shores of the Mediterranean and the Black Sea are always malarious at the commencement of hot weather, because in the absence of a tide there is none of that frequent salt washing and drainage, which purifies other European shores.

It is not only marshy, or low grounds, that engender malaria, although these are the situations that are most favourable to its production. All that seems to be really requisite, is the continued operation of the sun's heat on moisture stagnant upon, or near, the surface of the ground. I know instances in which ague has attacked persons living on a height of mountain limestone, form- a small table land below higher ground. Some swampy lands are not malarious; peat bogs, in particular, show a remarkable exemption from decomposition and effluvia of all kinds.

It is a curious fact that malaria seems to be more active at night, than by day. Its power seems to be diminished by the cultivation and dense peopling of districts where it has prevailed. The Italians date its development in the deadly Maremma from the time that the country was desolated by the Plague. This influence of the population is probably connected more with their activity than with their presence; for the ague disappears in proportion as the inhabitants drain the marshes and remove the source of the poison.

85. The morbid effects of marsh miasms are multiform: intermittent and remittent fevers of various types, are the most remarkable among these, and particularly affect the new residents in a marshy spot; but the older inhabitants suffer from diseases of

the liver and spleen, nervous affections, rheumatism, dropsy, and cachectic complaints, and are generally short lived. The first operation of the malarious poison seems to be on the quality and distribution of the blood: in the worst cases this liquid becomes speedily darker in colour, and otherwise altered, and accumulates to an extraordinary amount in the internal organs, where it then suffers still further in consequence of its stagnation and want of purification by the ordinary processes of excretion. The fit of an ague is the reaction (§ 16) of the vital powers against this cumulative influence of the poison on the blood: if the vital powers are strong, and the dose of the poison not overwhelming, the fit successfully removes the internal congestions, and partially restores the purity of the blood through increased excretion; but some poison being still in the system, similar effects are again produced after a longer or shorter interval; and so alternate attacks of ague, and intermissions, appear in succession.

One of the most remarkable characters in the diseases resulting from malaria, is the periodicity of their attacks, and the diminution or cessation of the symptoms in the interval. This is probably due to the alternate accumulation of the malarious influence in the body and the reaction of the vital powers against it.

86. There can be little doubt that there are other kinds of malaria besides those which cause intermittent and remittent fever (§ 80, 81). Yellow fever and plague are endemic diseases, most probably arising from aerial poisons. The propagation and severity of the latter, and perhaps even its very existence, is to be mainly ascribed to the filth and impurities of the towns where it prevails. These, however, are cognizable causes, whose operation in exciting and predisposing to disease, has been already noticed (§ 70—73, § 22).

Bronchocele and cretinism, and allied results of depraved nutrition, manifested in glandular enlargements, fibrinous and dropsical swellings of the cellular tissue, distorted limbs, stunted growth of the body, and imperfect development of the mind, are dependent on endemic causes; which are most probably miasms arising from the low marshy grounds of the deep valleys of Savoy.

Some other endemic diseases can also be traced to cognizable causes; the Guinea worm, seems to be due to drinking water containing its ova; the pellagra of Northern Italy, and the plica of Poland, are brought about by neglect of cleanliness, and unhealthy modes of living, and probably are both immediately dependent

on the production and propagation of a parasitic vegetable on the roots of the hair and skin.*

(2.) EPIDEMIC POISONS.

87. There is another group of diseases, which resemble the endemic in affecting many persons in the same place and at the same time (§ 81). But they differ in these respects, they do not regularly return at stated seasons (§ 84), and they are not confined to particular localities (§ 82), although they infest some more than others; they attack a whole district, a whole country—and sometimes almost a whole hemisphere—within a very short time; often coming on without obvious cause; prevailing for awhile, and then disappearing for an uncertain period; which may be for months, or years, or even for intervals too long to be remembered. These disorders are called epidemics, (ἐπὶ δῆμος), because they seem like a blight, or pernicious influence, blowing *on the people*; and therefore affecting a whole country at once.

88. The cause of these diseases is supposed to be something in the atmosphere; for the atmosphere is the only thing that is common to all the places to which the affection extends: but the nature of the epidemic poison is just as mysterious as the endemic. It is true that some diseases, which seem to prevail epidemically, may be traced to the cognizable qualities, cold, heat, dryness, and moisture of the air (§ 74, *et seq.*). Thus diseases excited by cold sometimes prevail, as epidemics, in the winter; those excited by heat, in the summer; catarrhs and rheumatisms abound in cold damp weather; croup and quinsy become common during the prevalence of a cold east wind in the spring; diarrhœa and dysentery are rife in the autumnal fruit season. Other disorders, again, such as dysenteries, fevers, and scurvies, have in some instances obviously arisen from deficient or contaminated food, bad water, or some other distinctly cognizable cause (§ 60, 70, *et seq.*). But as these causes all belong to the class of cognizable agents already noticed (§ 52, *et seq.*), they do not need to be adverted to here.

89. But there are diseases occurring epidemically which do not appear to have any discoverable connexion with season or temperature. Thus an epidemic influenza may come on at any season of the year, and rapidly spread through a country, and then cease as

* Robin, Histoire Naturelle des Végétaux Parasites. 1853.

unaccountably as it began, or it may break out simultaneously at distant parts where the temperature is exceedingly different.* So, too, diseases that are obviously excited by other causes, whether infectious or otherwise—as, for instance, typhus and scarlet fevers, measles, small-pox, and erysipelas,—sometimes prevail so extensively, and with such peculiar characters, that some common influence besides the agencies that usually produce them, must be admitted to be concerned in their sudden appearance and diffusion. The nature of this influence is unknown; but it is spoken of as *epidemic* (§ 87).

90. Various diseases, fevers, and inflammations, and many other kinds of ailments, at some periods assume a remarkable character in common, or *type* (as it is called); for example, they may be attended with unusual weakness, or unusual excitement, or a tendency to hæmorrhage. This is said to be due to an *epidemic or prevailing diathesis*, or *constitution*. Thus at uncertain times, fevers, wherever arising, and from whatever source, are always more low, typhoid, or adynamic, than usual; exanthematous diseases then generally partake of the same character; and even patients affected with inflammations will not bear depletion as they would at other times. Of late years, this low type has prevailed more or less, and may be contrasted with that of a period of thirty years ago, when an inflammatory diathesis was as common, and blood-letting was then advantageously employed even in continued fever.

91. It has been before stated (§ 88), that we are quite in the dark as to the nature of epidemic influences or causes of disease. Many conjectures have been advanced, some of them with much plausibility, although without any substantial support. Dr. Prout states that, shortly before and during the prevalence of the malignant cholera in this country, he noticed a slight but decided increase in the average weight of the atmosphere, as if from the addition of some ponderous gas. At the same time, he remarked an unusual acidity in the saliva even of healthy persons, and such an absence of lithic acid from the urine, that he was inclined to suppose the existence of a peculiar disposition to form oxalic acid, and to refer this to the same unknown cause which was active in the production of cholera (60). He suggested the possibility that

* The influenza of 1836 prevailed simultaneously in London and Cape Town, although it was then the summer of one place and the winter of the other. See "Annals of Influenza," by Dr. Theophilus Thompson. 1850.

some such subtile deleterious agent, as seleniuretted hydrogen, might be diffused through the atmosphere and produce the pernicious results observed. Such an agent might be evolved from volcanoes, and it is a curious fact that several severe epidemics have been known to be preceded by volcanic eruptions. This has not however been found to be always, or even often, the case. Neither do volcanic countries suffer the first, or the most intensely from epidemics, as they ought to do, if this supposition were based on fact. Electro-magnetic influence, and abnormal production of ozone, are among the assumed causes of epidemic disorder, and the assumption has more of probability on its side, on account of the ubiquitous character of these agents. But here, again, there is no other evidence for the opinion to rest upon, than a few equivocal observations regarding the occurrence of auroræ boreales, and disagreeably odorous fogs (said to contain ozone), coincidently with certain epidemic invasions.

92. Many analogical arguments have been adduced in support of a favourite notion of Linnæus, namely that epidemic diseases are caused by animalcule tribes. This hypothesis has been ably advocated by Sir H. Holland,* Dr. Henle,† and others. Before I had seen the opinions of these authors, I had, in my lectures, stated some arguments which appear to favour this notion, and which will be noticed again when speaking of infection. It may here, however, be remarked, that the chief facts which afford a countenance to the view are the following:—1. Epidemic diseases resemble the effects of the blight insects, by appearing and disappearing without evident cause, in uncertain places and at uncertain periods. 2. Unusual swarms of insects, and various epidemic visitations have been frequently remarked as occurring together, although it must be confessed that no uniformity has been found to obtain in either the characters of the insects, or the diseases. 3. Fresh proofs are continually coming under notice of the existence of parasitic animals and plants in living animals, often, too, unmistakeably presenting themselves as causes of disease; this is seen in intestinal worms and other entozoa, the acari of itch, and the rot-worm of sheep.‡

* Medical Notes and Reflections, 1840, p. 597.

† Pathological Researches, British and Foreign Medical Review, April, 1840.

‡ Vegetable parasites, too, often appear in the same light, as instanced in the mycodermatous vegetations of porrigo, and pityriasis versicolor. (See Sprenger, Canstatt's Jahresbuch. 1851.) And in the parasitic algæ of aphtha. (See Robin, Histoire Nat.

4. The history and symptoms of such epidemic diseases, as cholera and influenza, are in no way inconsistent with the hypothesis that they are caused by the sudden development of animalcules from ova received into the blood. It must be finally stated, however, that there is an entire deficiency of all direct observations which could confer support on this hypothesis; and, perhaps, it may also be objected to it, that the seasons in which epidemics sometimes appear, are not always those most favourable to the development of animalcule life.*

(3.) INFECTIOUS POISONS.

93. The terms *infection* and *contagion* are applied to the production of a disease by the influence of a morbid matter proceeding from the body of a person who is, or has been, the subject of the disorder. They imply, in short, disease produced by *communication*. The proofs that disease is sometimes thus propagated from one individual to another are, first, the general one, that those who have intercourse with the sick, are affected in much greater numbers than those who have not (§ 12); and, secondly, the direct and individual act of infecting a healthy person with matter taken from a person in disease. This latter plan, although available only in some forms of infectious disease, may nevertheless be considered as a sufficient proof of the general fact of contagion—that is, of the power of disease, under certain circumstances, to propagate itself.†

94. I have just alluded (§ 93), to there being different ways in

des Vegetaux Parasites. 1853.) Gruby, Comptes Rendus, t. xlii. Bennett, Trans. Royal Soc. Edin., 1842.

* The prevalence of the south-east wind has been observed to be particularly favourable to the increase of both cholera and influenza; and I cannot but think that this has some connexion with the general tendency which the former shows to spread chiefly from east to west. Has the morbific power of this wind aught to do with the haziness of the air which commonly prevails with it?—a haziness perceptible in the country remote from smoke, and quite distinct from fog? What is this haze? In the west of England, a hazy day in spring is called a *blight*. Ehrenberg has discovered by the microscope that wind deposits a fine dust, even on mountain tops, which has almost an identity of character wherever found, and which contains in addition to various earthy and oxy-metallic matters, fragments of fossil shells and shields of extreme minuteness. Organic exuviæ of this kind have been found on the coast of Africa, which seem to be the same with deposits lying near the summits of the Andes. Numerous facts seem to indicate that there are currents in the upper regions of the atmosphere that are equal to the task of transmitting subtile organic materials from one hemisphere to the other.

† Some facts, and able arguments, tending to establish the existence of contagion in cholera and other epidemics may be found in a paper entitled "The Exciting Causes of Epidemics" by Professor Alison, in the Brit. and For. Med. Chir. Rev. Jan. 1854.

which infection may operate; and may now specify three distinct modes in which it may do so:—

(1.) Infection through wounds, or an abraded surface; this is what is commonly misnamed inoculation: it is instanced in hydrophobia, where the morbid matter is contained in the saliva, or guttural mucus of the rabid animal; and in cow-pox, where it is afforded by a specific vesicle.

95. (2.) Infection by contact, different parts of the body being, however, only susceptible of different diseases; this is *contagion* properly so thus called: thus the urethra and conjunctiva only suffer in gonorrhœa, the vicinity of the external openings of the passages in syphilis, the skin in scabies, the scalp of the head in porrigo—in all these cases the morbid matter that effects the mischief issues generally from similar parts.

96. (3.) Infection by exhalations in the breath, or cutaneous or other secretion; conveyed through the air to the mouth and air passages: as instanced in the case of measles, scarlatina, hooping-cough, typhus, and other infectious fevers.

97. Some diseases are capable of propagating themselves by several of these modes; small-pox, for instance, may be communicated by infection through punctures in the skin (§ 94), by application to the eye (true *inoculation* (§ 95),—and through the general mass of the respirable air (96): probably inoculation might also be effected with other febrile poisons, if they could be procured in the same palpable form as the matter of small-pox. All this merely shows that the matter of infection can exist suspended in the air, as well as in a fluid or solid state; and that it may accordingly get access to the system by different avenues as it is in the one or the other of these. It is pretty clear, too, that the poison of infection may sometimes be conveyed by articles of clothing, bedding, or household furniture. This is the case with scarlatina, small-pox, and perhaps the plague, but in these matters popular prejudice generally goes beyond the truth.

98. Many of those who are sceptical regarding the reality of infection, direct their objections only against aerial communication, and do not question the other modes. But the real difficulty of the case is, not that infectious matter may be diffused through the air—our sense of smell informs us that animal effluvia are constantly so diffused—but that infection can take place by any mode; that is, that disease should be able to propagate itself. There are only

two parallel cases in nature, in which analogous actions take place. One is that of what is called septic matter, leaven, or ferment; a little of which being introduced into organic matter promotes changes and decompositions in it.—"A little leaven leaveneth the whole lump." This is supposed by Liebig and other chemists, to be a chemical action; *operating in the manner of heat, by altering the molecular relations and affinities of compound principles; as,* for example, when some such protein compound as gluten in a certain state of decomposition, promotes the conversion of starch into sugar, and of sugar into lactic acid, and then this into butyric and carbonic acids. It has, on the other hand, been maintained by Turpin, Cagniard De la Tour and others, that fermentation is caused by the production and growth of living molecules of a vegetable nature (torulæ), which have the power to modify the affinities of the material in which they are developed, and that it spreads by the multiplication of these living bodies. If this notion be based in truth, it transfers the explanation of leaven or ferment, into the next category (§ 99).

99. The other case analogous to the propagation of disease by infection, is that of the vital power of generation; in this case, organized matter propagates itself in the animal and in the vegetable world. Does then the poison of contagion consist of animal ova, or vegetable seeds? Are infectious diseases results of the invasions and operations of living parasites disturbing in sundry ways the functions and structures of the body, each after its own kind, until the vital powers either succumb before them or succeed in expelling the invaders from the system? (§ 16). Such an opinion has been many times proposed, and is, in a degree, implied in the term *incubation,* (sitting on eggs to hatch them), which is commonly applied to the period that intervenes between the reception of the infection and the first appearance of the symptoms. The notion, indeed, receives support from the phenomena of itch, which certainly infects through an insect, the itch-mite, and spreads by this animal's propagation; and from those of porrigo, or favus, which is now known to depend on a minute parasitic vegetable, and to infect through its seeds or sporules.* It may however be objected, that these are instances of mere local disease, and by no means parallel with the case of infectious fevers, or syphilis, in which the whole system is affected.

* Schönlein, Muller's Archiv., 1839, p. 82. Gruby, Gazette Médicale, Juillet 17, 1841. Robin, Hist. Nat. des Vegetaux Parasites. 1853.

It might be expected that small-pox and cow-pox would throw some light on this difficult subject, because the infectious matter of those disorders is found in the incipient pustule; but this has not hitherto proved to be the case. M. Gruby states that he has discovered a few animalcules in the lymph of the variolous vesicles, but its disease-producing power has not been traced to these creatures.

100. There are certain general properties in all forms of infection which seem rather to favour the notion that they are dependent upon parasitic creatures, and which further deserve to be mentioned on account of their practical importance. Infectious matter is destroyed by a temperature that is higher than 120° Fahr., and by strong chemical agents, especially chlorine; its activity is impaired by cold; and in the case of aerial infection, is rendered harmless by intense cold and free ventilation. Hence many infectious diseases cease when hard frost sets in. On the other hand, warmth, closeness, and filth, increase the virulence of the mischief, and become, as it were, a nursery of pestilence. Nothing tends to promote the spread of an infectious disease more than crowding together many people who are suffering under it. Each one is then a separate source of contagion; and as these sources are multiplied in an apartment, the contained air becomes more contaminated in proportion. This is the chief reason why medical attendants and nurses escape infection much more rarely in fever hospitals and wards, than they do in hospitals where the fever patients are widely distributed among persons suffering from other disorders.

The greater number of infectious disorders, especially those which have the character in the most marked degree, leave the system more or less free from liability to their recurrence. This immunity, however, diminishes somewhat with lapse of years. A large proportion of those who have once had measles, small-pox, or hooping-cough, never take these disorders again, even although fully exposed to the infection. Some, however, do catch them again after the lapse of many years; most of these exhibit a much milder type of the affection than is usual in a first attack. This comparative security against a repeated infection is involved in much mystery, but it is attributed by Liebig, and others who favour the zymotic, or fermentation hypothesis, to the exhaustion of a certain material which is the subject of the fermentative change, and which is considered to be not easily again reproduced.

All this is, however, pure hypothesis, and unsustained by any trustworthy facts.

[The too frequently repeated visitations of epidemic cholera, have left behind them a few hints that may help to guide future investigators in the right direction, when they seek to determine the nature of the concealed causes of epidemic and infectious diseases. There can be no doubt that cholera is caused by some subtle poison which travels. Its path may be followed almost as if it left visible traces of its footsteps. It is equally clear that it avails itself of material means of transport. Instances have occurred again and again, where the clothes in which cholera patients have died have communicated the disorder to healthy persons. But it is no less clear that this subtile agent requires a prepared recipient in order that it may become operative for evil. Comparatively few persons are susceptible to its action, even when it is rendered very intense by confinement in impure and badly ventilated apartments. Cholera, then, very aptly illustrates what has been already said regarding the necessity of predisposing and exciting influences conspiring for the production of disease. The human body is capable of being predisposed to become affected by cholera through the operation of various debilitating agents, but it does not even then contract the disease, unless it is exposed to action of the peculiar subtle poison that broods unseen in the air, and marches through its transparent spaces, bent on the errand of death.

But there is this highly important and interesting peculiarity about the poison of cholera,—although it propagates itself, it is not able to do so, unless a certain material is provided for it to feed upon at the time. It must have moisture and exhalations from decaying organic matters, or it cannot thrive, and reproduce itself. If these essential supports are wanting, it makes no progress, and disappears. The cholera poison spreads centrifugally from any focal point in which it has been called into existence, as waves of water extend round a spot into which a stone has been dropped, growing weaker, however, as it spreads, and at last giving no appreciable token of its existence, unless it crosses some locality in which the material elements of the poison are collected in a very concentrated state, some fated spot in which moisture and the products of decomposition dwell. Then the active poison is again called into existence out of these matters. A new focus

of infectious influence is made, and from this the epidemic contagion again spreads centrifugally as from a new centre of departure. The latent material of the cholera poison may be likened to the charcoal, nitre and sulphur, that lie side by side in the grains of gunpowder. The explosive substance is there, but no explosion takes place until the quickening spark comes. Then the consuming flame breaks out. Moisture and putrefactive effluvia are the rough material of cholera poison, but this material is never worked into its effective and finished state, unless under the presence of poison already complete and active. Hence it is that the cholera poison travels, but only through regions of moisture and filth; and hence, too, it is that the disorder grows milder as it spreads, but again breaks forth in certain spots with renewed virulence from time to time. It is curious that either the zymotic or the parasitic theory of infection may be supposed to receive support from these considerations. It may be deemed either that the infection finds new material that it can change into a morbific agent like itself by fermentation; or on the other hand that the living parasites alight upon deposits of food which they are able to assimilate and convert into an offspring like to themselves. So much for hypothesis.—*Note by Dr. Mann.*]

101. It may be useful again to point out the characteristic peculiarities of infectious, endemic, and epidemic diseases; for these peculiarities are so many proofs of the reality of infection viewed as an immediate cause of disease.

Infectious diseases first attack individuals in some given locality, and then gradually spread in the vicinity, or in the direction in which there is most human intercourse. If care be taken, early and completely to separate the diseased from the healthy, the disease does not spread among the latter.

102. *Endemic* diseases attack many individuals simultaneously in certain confined localities, (§ 81), and do not spread beyond these localities; separation of the sick from the healthy does not give the latter security; but removing the healthy to another spot does.

103. *Epidemic* diseases simultaneously attack many individuals over a wide extent of country (§ 88): but do not increase particularly in the vicinity of those first affected, nor yet in proportion to intercourse with these, but rather in proportion to the

prevalence of certain conditions that are of the nature of predisposing or determining causes (§ 19).

104. It must always be borne in mind that some diseases are suspected to originate and spread by more than one of these modes. This is probably the case with typhus fever, plague, cholera, and dysentery. It has been already mentioned that infectious diseases, like small-pox, scarlatina, and measles, are occasionally increased and modified by epidemic influences (§ 90, 91); the same thing may also be stated of some endemic maladies. The unquestionable aggravation of contagious and epidemic complaints in consequence of endemic impurities, (§ 85), makes it plain that all these several causes may operate conjointly. It is under such circumstances of aggravation, combined with strongly prevailing predispositions, induced by famine (§ 21), fatigue (§ 23), confinement (§ 22), defective supply of air (§ 24, 72), or mental depression (§ 28), that epidemics not only spread more rapidly, but also assume so intense a form, that they become very destructive, and so earn for themselves the right to be called malignant and pestilential.

The direct operation of most of this class of morbific causes is depressing, so that where these influences are strongest, the resulting disease is the most sure to wear the character of *adynamia, asthenia,* or prostration of the vital powers. As they exhibit influences directly noxious to life, they are commonly designated *specific poisons.* But there is in the system the antagonist principle of vital resistance (§ 16), which leads to various processes of reaction, exhibited in different degrees, according to the relative strengths of the poison and of the resisting power, and often also according to the absence or presence of cognizable agents which act at the same time as predisposing, determining, or co-operating causes. For instance, in warm weather the poisonous influences are generally strong (§ 84, 100), and the bodily powers weak (§ 24); the resulting disease is then consequently one of more complete adynamia. In moderately cold weather, on the other hand, the specific poison is less intense, and the system more ready to react, not only against it, but also against the cold which is operative with it; this leads to a more inflammatory type in the consequent disease (§ 79, 81).

The zymotic theory of epidemic, endemic, and infectious influences, affords a very reasonable explanation of the decomposition and putrefaction which they work in the blood, and subsequently

in all the fluids and solids of the body. Dr. Carpenter points out* that there is one condition very likely to dispose the body to suffer from their injurious influence, namely, the presence in the system of an azotized matter tending to decomposition, whether arising from a rapid disintegration of materials of the body, as occurs after child-birth, accidental injuries, surgical operations, excessive fatigue, or extreme privation,—or caused by impaired action of the depurating organs of respiration and excretion, in consequence of close confinement in impure air, exhaustion of vital power from intemperance and habitual excesses,—or directly introduced in the form of unwholesome food in a decaying state (§ 35).

105. The means that have been found most effectual in preventing the spread, and of counteracting the effects of zymotic poisons are chiefly of the nature of antiseptics, which may operate without as well as within the body,—and stimulants, tonics, and eliminants, whose influence is limited to the living structure. Of the numerous class of agents to which an antiseptic property is ascribed, there are two which especially deserve mention, as having been proved to be highly useful as disinfectants, or purifiers from the contaminating matters of infection and malaria; these are chlorine and charcoal. Chlorine seems capable of destroying all kinds of zymotic poison, and may be usefully employed to purify the air, walls and floors of infected houses; and in a liquid state added to excreted matters, it removes their fœtid effluvia. But its acrid qualities limit its use in inhabited rooms, and it can be applied only in a very diluted state as an internal or external remedy. Charcoal, recently prepared, is equally efficacious as a purifier, and its innocuous properties make it very eligible for use in a great variety of ways. Placed in shallow dishes in infected rooms, it speedily absorbs from the air all offensive effluvia, and destroys all bad odours.† Applied in a poultice to sloughing sores or ill-conditioned ulcers, it accelerates the decomposition and removal of the dead parts, whilst it removes their fœtor, and relieves much of the

* Brit. and For. Med. Chir. Rev. Jan., 1853.

† Dr. Stenhouse has shown that charcoal has no antiseptic property in itself; in fact it hastens the decomposition of any organic matter with which it is placed in contact. Its purifying influence depends on its property of absorbing and condensing in its pores any gases or vapours, and by this condensation promoting their oxidation and conversion into innocuous matters. Thus sulphuretted hydrogen is converted into sulphuric acid and water; carburetted hydrogen into carbonic acid and water; cyanogen into carbonate of ammonia, &c.

pain and irritation attendant on them. I have employed it with great advantage in an enema with opium and sulphate of copper in the worst forms of dysentery, in which the putrid and bloody discharges speedily lead to fatal prostration; it always relieved the dysenteric symptoms and corrected the fœtor of the discharges, and in two cases of the worst aspect the patients recovered. How far the use of charcoal in a respirator, as recommended by Dr. Stenhouse, may prove a safeguard against infection, can only be proved by extensive trials; and in this as well as in many other applications, it well merits the attention of the profession. Its utility in gangrene and fœtid abscess of the lung, in empyema, and advanced stages of tuberculous disease, can scarcely be questioned.

The other remedies, to be opposed to the influences of zymotic poisons, are stimulants, which counteract their depressing influence; tonics, which, by increasing the tonicity of the vascular system, prevent the visceral congestions which are among their worst effects; and eliminants, which promote the expulsion of the poisons from the body. The application of these remedial agents in the cure of zymotic diseases, belongs to special therapeutics; but their use as preventives, to counteract the operation of the poisons, as exciting causes, is worthy of attention in this place. It has often been remarked that a considerable proportion of the persons who are exposed to malaria or infection do not contract the diseases which result in other cases, and yet some exhibit proofs that the poison has really entered their system. Thus in aguish districts a healthy person may have a severe headache; but this soon passes off. During the prevalence of scarlatina, such an individual may have a sore throat of a day's duration; and when cholera prevails, few escape without more or less of a transient diarrhœa. But the morbific influence goes no further, being successfully resisted and probably expelled by the natural powers. Now there may be others in whom these natural powers are inadequate to this task, unless they are aided by some of the remedial agents before mentioned. Thus to persons with languid circulation and deficient strength, a moderate amount of wine or other proper stimulant, judiciously combined with food at meals, may supply the wanting vigour of resistance. To those with a weak soft pulse, with consequent liability to congestions, small doses of quinine, or other tonic, repeated twice or thrice daily, may

sustain the balance of the circulation against the operation of the cause; and finally, to those whose excreting functions are torpid, the assistance of such medicines as may moderately augment the defective excretions, may prove the means of delivering them from the ulterior effects of the poison. In illustration of this last suggestion I may adduce the well known fact ascertained by Orfila, that arsenic and other poisons might be given to animals without deleterious effect, only so long as they were combined with diuretics and other eliminants.

CHAPTER II.

PATHOLOGY (PROPER)—THE NATURE AND CONSTITUTION OF DISEASE.

106. Disease is a change from the natural condition of the function or structure of the body, (§ 6, *et seq.*); but the change is generally more or less complex, involving several elementary functions or structures; it is therefore obvious that we cannot obtain an accurate knowledge of the nature of disease, until we have carefully studied the component parts of which it is made. As the anatomist or physiologist examines structures and functions by separating or analyzing them into their constituent parts, before he enters on their contemplation as a whole, so should the pathologist study the constituent parts, or elements, of *disease*, before he attempts to understand their combinations.

A neglect of this precept has greatly retarded the advancement, nay, even the formation, of pathological science. Men enter upon the very complex problems of *inflammation* and *fever*, before they have made themselves acquainted with the elementary properties of textures, or even of vessels. The result has been, that the most profound reasoning and ingenious speculations have been wasted on such nonentities as spasm of the extreme vessels, and increased action of the capillaries: and even observation has been confused by the complexity of the subjects that are too suddenly brought before it.

The chemist, while pursuing his examinations, finds that there are some principles or elements which he cannot analyze or divide further; these he calls ultimate or primary elements: others, again, he discovers to be compounds, which he can resolve into primary elements; but which are so simple, occur so constantly, and act so distinctly in combining, and in giving properties to complex matter, that he is induced to name them proximate principles, or secondary elements. The physicist or natural philosopher, makes a similar distinction in the matters with which he deals.

107. So too it should be with the physiologist and pathologist.* There are the healthy and diseased *primary*, or *ultimate elements* of *structure*—muscular fibre, nervous matter, vascular structure, and the elementary tissues of membranes, glands, skin, and other like textures; and there are *primary elements*, healthy and diseased, of the *functions* of these same structures—irritability, tonicity, and nervous properties, to which we may add, because at present we cannot analyze it, the power of secretion and nutrition; and lastly, there are the constituents of the highly important fluid which furnishes the material of the elementary tissues, namely the blood, which are also subject to morbid alterations of structure and derangement of function. But there are also *secondary* or *proximate elements* of disease, composed out of these primary elements, but which are themselves simple, in comparison with the complex conditions of disease that they combine to produce.

108. But again, disease, affecting the several elementary and proximate structures and functions of the body, varies both in *degree* and in *kind*; the degree, including *excess* and *defect*, alterations of a *plus* and *minus* nature: and kind, relating to changes not coming under either of these heads, but characteristically expressed by the term *perversion*. By employing these several distinctions while considering deviations of structure and function, we are able to construct a simple and comprehensive classification, which embraces within itself all the most important topics of general pathology.

* I pursued this synthetic mode of teaching general pathology, in my lectures, since the year 1839. I am not aware that it has been as fully used by any other writer, although several (among them Andral and Carswell) have partially recognised it in classing the objects of morbid anatomy; and my friend, Dr. Symonds, has alluded to the parallel case of chemistry, and has actually employed the term, proximate principles of disease, in the same sense in which I use it.—*Library of Practical Medicine*, vol. i., *Pathological Introduction*.

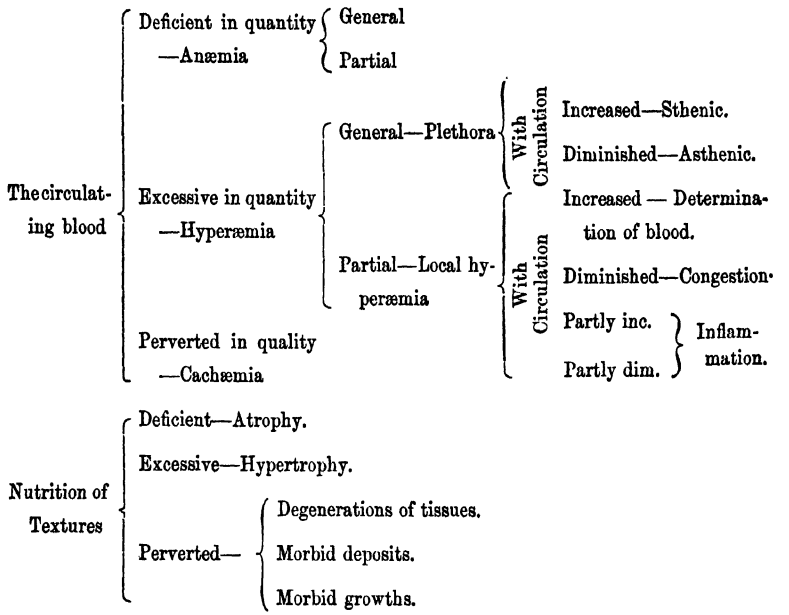
109. The following table presents this classification, so far as the primary or ultimate elements of disease are concerned.

PRIMARY ELEMENTS OF DISEASE.

STRUCTURAL CONSTITUENT.		ITS FUNCTION.	DISEASE. STRUCTURAL DISEASE.
Contractile fibre		Irritability. Tonicity.	
Nervous structure	Tubular (the conductor of nerve force.)	Sensation. Voluntary motion. Involuntary motion,	
	Vesicular (the generator and combiner of nerve force.)	(excited motor action.) Sympathetic action	Excessive.—Hypertrophy.
Secreting structure		Secretion.	
Elementary components of blood	Red corpuscles. White corpuscles. Fibrin. Albumen. Oil, and combustive matters. Inorganic ingredients (saline and mineral). Water.		Deficient.—Atrophy. Perverted.—Degeneration.
Elementary changes in the blood	By respiration. By secretion. By nutrition. By foreign matter.		

110. In treating of the proximate, or secondary, elements of disease, we are constrained to be more arbitrary and less comprehensive; lest we should encroach on the domain of special pathology. There are, however, certain changes in the state and action of the vascular system, and of the nutrient function so intimately connected therewith, which are of so comprehensive a character and so wide an extent, as to belong to the province of general pathology; but which nevertheless comprise alterations in two or more of the above named ultimate elements of structure and function (blood constituents, secretion, irritability, tonicity, &c. § 109). These also may be tabulated as the proximate elements of disease.

PROXIMATE ELEMENTS OF DISEASE.



These primary and secondary elements of disease come, then, under the especial notice of general pathology. By studying them we form an acquaintance with the materials of disease, and their general relations; but we also learn how special diseases arise, and of what they consist: how they produce their phenomena and effects, and how they are to be known, distinguished, and classified. Out of a correct and sufficient knowledge of these elements, combined with the comprehension of the properties of remedial agents, is to be deduced the rational method of preventing, relieving, and curing disease; in other words, a rational practice of medicine.

I readily admit that our knowledge of these elements or principles of pathology is as yet so limited that it cannot take rank as a complete science; but I think that the attempt to describe and illustrate them will be useful, not only by communicating direct information, but also by pointing out where investigation is needed: thus suggesting fit subjects for further research.

FUNCTIONAL OR DYNAMIC DISEASES.

PRIMARY ELEMENTS.

SECTION I.

PROPERTIES OF THE MOVING FIBRE.—IRRITABILITY.

111. IRRITABILITY, irritable contractility, or the property of contracting on the application of certain stimuli, is the distinctive characteristic of muscular fibre.—Some physiologists, Prof. Müller and Dr. Marshall Hall among them,* maintain that this property is not inherent in muscular fibre, but is, in some way, seated in the nervous tissue distributed on it. Many more, however, hold with the view of Haller, that the muscular texture itself, is intrinsically irritable, and that the nervous influence is but one of the many stimuli that are capable of calling the irritability into active operation. And this seems the more probable state of the case—there is no doubt whatever that the irritability of the muscular fibre remains for some time after all vital susceptibility and power have been destroyed in the nerves by narcotic influence.

There is one condition which is well known to be more or less essential to the continued existence of muscular irritability. This is a due supply of arterial blood. Such a supply seems to act in a two-fold way—In the first place it furnishes the material of muscular nourishment, and this is necessary, because the muscular movement is a destructive or disintegrating process—some portion of the muscular substance is destroyed with every movement which it makes. But in the second place, arterial blood furnishes the oxygen which is requisite to effect the disintegration of the organ-

* Dr. M. Hall ascribes irritability to the spinal marrow ; but he mentions an experiment which is conclusive against his own view :—"During the half lethargic condition of the frog in winter, the entire cerebrum and spinal marrow may be removed, by slow degrees, at considerable intervals ; the circulation is nevertheless good."—Gulstonian Lectures, 1842, p. 60. The irritability of the heart, therefore, is unimpaired by the removal. The experiments of the late Dr. John Reid, on muscular irritability, go far to prove that it is a vis insita. Mr. Bowman and others have seen, with the microscope, a single muscular fibre exhibit contractile power, when freed from all attachments and nervous connection.

ised material. It is an interesting fact that the continuance of muscular irritability after the general death of the system, is generally proportioned in different species of animals to the activity of the respiratory functions. Where the respiration is the most active, muscular power is the greatest. Muscular contractility is, however, less dependent upon the presence of oxygen in cold-blooded animals than in warm, and involuntary muscles also, are somewhat more independent of its influence, than voluntary—the heart continues to contract for some time after venous blood alone is supplied to it, and after all circulation in its coronary vessels has ceased. M. Brown Séquard demonstrated the power of arterial blood to cause the contractility of muscular fibre in one very ingeniously devised experiment. He found that in the body of a decapitated criminal, all trace of muscular irritability had disappeared twelve hours and a half after death, and cadaveric rigidity supervened. Forty-five minutes after this, he began to inject arterial blood into the veins by half-pints at a time. He continued to do this at intervals for 35 minutes, and he then found that several of the muscles had regained their irritability. It is highly probable that the contractile power is a direct result of chemical decomposition of an oxidizing kind. MM. Becquerel and Breschet have shown that heat is disengaged during muscular contraction, and Prof. Matteucci thinks that he has proved the evolution of electricity by means of his "frog galvanoscope." Some recent microscopical observations, made upon some very beautiful specimens of muscular fibre prepared by Mr. Lealand seem to indicate that these chemical changes operate mechanically by causing the cells or vesicles of which the ultimate muscular fibres are composed, to change their dimensions.* Professor Carpenter considers that the ultimate fibres of muscles are made of rows of drum-shaped vesicles placed end to end, and adhering together by their flattened surfaces, and he thinks that these vesicles severally contract their longitudinal dimensions, and bulge out their sides, whenever the fibre is shortened. In this view the oxidation of the complex organic principle contained within the vesicle (probably globulin and hæmatin), causes change in its form, and the change of form in several vesicles produces the contraction of the fibre.

* Carpenter's "Principles of Hum. Phys.," p. 296. Dr. Sharpey's "Quain's Anatomy," fifth Ed., p. 168.

112. (1.) Excessive strength of muscular contraction is exemplified in the violent action of the heart and other muscles during great exertion and excitement; and also in the extraordinary efforts of delirious patients, who can master persons ordinarily stronger than themselves. This exaltation of the natural property may depend on undue stimulus, as when too much blood passes through the heart, or when too much nervous influence is developed, as in the case of the delirious patient; or it may arise from the muscles being over-fed with blood, which happens in the continued increased action of the heart, where there is tendency to hypertrophy. It is probable that when extraordinary efforts are made during delirium and mental excitement, these are effected in consequence of a greater number of muscular fibres being *simultaneously* called into play, rather than in consequence of the fibres being then more strongly contracted.

113. (2.) Inordinate readiness or quickness of contraction constitutes high mobility of muscle, a very slight stimulus being then sufficient to induce it to contract. This often co-exists with want of power or completeness in the contractions. It is exemplified in the irritable heart, which, although acting very frequently, does not expel its contents so vigorously as in health; so that whilst its own action is strong, the pulsations in the vessels of remote parts are weak, and the limbs partially cold. It is seen in the quick nervous movements of irritable persons, who are at the same time wanting in tone. The bowels show it in that irritable looseness formerly called lientery, in which food is quickly passed little altered; and it is instanced in the irritable bladder, which will not hold even an ounce of urine. The pathological cause of this kind of inordinate irritability is either an undue flow of blood to the muscle, sometimes combined with an irritating quality in the blood itself, or a predominance of irregular nervous influence, which unduly excites the contractility: thus it is often induced by irritations applied to the motor nerves. The most

remarkable example of this kind of diseased contractility is exhibited in the extreme case of *convulsions* or *clonic spasms*—that is, sudden contraction, alternating with relaxation; this is seen in chorea, epilepsy, and convulsive hysteria, where it affects the voluntary muscles; and in the palpitating heart, which beats irregularly and out of rhythm.

114. (3.) An unusual duration of muscular contraction constitutes *tonic spasm* or *cramp*, in which the action is strong, continued, and not alternated with relaxation. Such spasm is not unfrequently felt in the calves of the legs; and is sometimes experienced in the different muscle-covered canals, the gullet, the stomach, the intestines, the glottis, and the bronchi. In most of these cases, the contraction is accompanied by pain more or less severe, and may lead to serious obstruction to the function of the affected organ. When in a more moderate degree this form of disordered contractility is present and affects the voluntary muscles generally, it constitutes catalepsy, in which, the limbs retain whatsoever attitude they are placed in, until the spasm is over. In its extreme condition it is known as tetanus, in which the spasms are so violent and so enduring, that they may be said to squeeze the patient to death. The pathological cause may be in this, as in other modifications of irritability, either an irregular supply of blood to the muscle, or irritation, direct or indirect, of the motor nerves by which the muscles are excited.

115. *Remedial measures.*—These should depend on the cause of the excessive irritability. Where there is increased flow of blood to the part, blood-letting, the application of cold, derivants, sedatives, and other remedies suitable for the removal of determination of blood, will be proper. Firm and continued pressure on muscles affected with spasm or cramp, will promote their relaxation. I have succeeded in opening the jaw in trismus, by using strong steady pressure on the masseter muscles. Where the cause is nervous irritation, narcotics are the most effectual remedies; and some of these, from their peculiar efficacy in allaying spasm, are called antispasmodics. The most powerful are, stramonium, belladonna, sulphuric æther, chloroform (taken into the stomach or inhaled), opium, and Indian hemp. Where irritability is combined with weakness, tonics are often serviceable, especially the metallic preparations, and bark. In such cases the muscles are usually weak and ill-nourished, and their excitability is dependent on

exalted function of the excitomotory nerves; the remedies adapted to this state of things will be noticed when speaking of nervous diseases.

116. Muscular contractility may be *deficient* in either of two ways. (1.) It may be wanting in force (§ 112); as when the voluntary muscles are weakened during severe illness, after fatigue (§ 68), or under the influence of a depressing poison or shock (§ 55); the same is also illustrated in the debility of the heart under similar circumstances, in faintness, and in the sinking which precedes death. Weakness of this kind may be caused by exhaustion from previous exertion, or by want of the due supply of blood necessary to maintain the muscular function (§ 111); or it may proceed from an influence which positively depresses or destroys the muscular power, as when sedative poisons like tobacco and sulphuretted hydrogen are taken; and probably concussion and other violent injuries to the organization act in the like way. The extreme effect of these agents is that they cause paralysis, or complete loss of irritability, which, affecting the heart, constitutes death by syncope. Muscles sometimes lose their irritability in consequence of the operation of more gradual causes, like rheumatic inflammation, the action of lead, &c. Muscles may be reduced in power by over-excitement or exertion on the one hand, but so also they may by disuse on the other: this is exemplified in the paralysis of the sphincter which follows from over distension of the bladder, torpor of the bowels which ensues after the operation of an active purgative, and in the weakness and ultimate palsy of the muscles of an anchylosed limb.

117. (2.) Muscular contractility may be deficient in readiness to act (§ 113), as seen in the sluggish movements of persons whose muscular irritability has been lowered by opium; and evinced in the slow pulse caused by digitalis, and by some cerebral affections; in some cases also by bloodletting or low diet. It is by no means clear why the same agents should, in some cases, lower the strength, and in others retard the readiness to contract: in many other respects, also the laws of irritability require further investigation. A benumbing degree of cold greatly reduces the irritability of the muscles; yet the sudden dash of cold water will sometimes restore contractile power which has been reduced by exhaustion or sedatives.

118. Although it has been shown to be most probable that

nuscular irritability is not *derived* from the nervous system, yet it is no less clear from the illustrations already given that it is very much under its influence. Nervous action is the stimulus provided for calling up the latent and inherent contractility of the voluntary muscular fibre; and through the nerves the motions of the involuntary muscles also are influenced, as instanced by the operation of mental emotion on the action of the heart (§ 69). Hence diseases of muscular action rank with nervous diseases. Thus, disease of the brain may cause a cessation of muscular motion by suspending volition; and disease of the spinal marrow, or nerves, may do the same by intercepting the influence of the will: in either case, motion of the muscle ceases, not from disease in itself, but for want of its proper stimulus. In fact, under these circumstances, muscular irritability sometimes accumulates (§ 111), and is brought into action, by slight impressions reflected from the spinal marrow. Thus, in complete paraplegia, or loss of motion of the lower half of the body, convulsive movements may be excited in the lower extremities by tickling the soles of the feet or merely pinching the skin: in other cases of paralysis, they may be produced by electricity.

119. *Remedial measures.* These, of course, should vary with the cause of the defective irritability; where this proceeds from exhaustion following long-continued exertion, repose is obviously necessary. But even here, in extreme cases, and more particularly if of the nature specified in the second division (§ 117), it may be necessary at once to excite the deficient irritability by stimulants, especially of the more diffusible kind, such as ammonia, brandy, other spirits, and essential oils; at the same time the feeble circulation may be aided by the use of heat and frictions. The large quantity of stimulants that can be borne by patients whose irritability has been reduced by accident or disease, is a remarkable feature in their history. A person faint from great loss of blood (§ 71), a crushed limb (§ 52), an extensive burn, or a sedative poison, will bear four or five times more brandy than would be sufficient to intoxicate him under other circumstances. Electricity and the dashing of cold water, should be mentioned among the means that serve temporarily to excite defective irritability. Strychnia and cantharides given internally, are reputed to restore power to paralysed muscles; but the same agents act much more energetically when directly applied to the affected part through blisters. So

likewise stimulant frictions, warm douches, and other means that tend to promote a vigorous circulation throughout the weakened muscles may assist in restoring their strength: generous diet, with tonics and healthy air, render the blood richer in the plastic matters by which the muscles are nourished.

SECTION II.

PROPERTIES OF THE MOVING FIBRE—TONICITY.

120. Tonicity, or tone, is a property possessed by all muscular structures, whether voluntary or involuntary, as well as by some other textures which are hardly accounted muscular. It is expressed by a tendency to slow, moderate, and permanent contraction, not essentially terminating in relaxation; it keeps the parts in which it resides in a certain degree of tension. It is seen in the retractation of a living muscle when divided in the operation of amputation of a limb, which takes place to a considerably greater extent than it would in a dead muscle. It holds muscles and limbs in their places when at rest, and out of their places when dislocated: when one set of muscles is paralysed, the tone of their antagonists draws the parts in connection with them in an opposite direction, as seen in paralysis of the portio dura of one side of the face. A similar property is exhibited by the intestinal tube, the urinary bladder, and the air tubes; it also resides in the middle coat of the arteries, and gives those tubes a constant tendency to contract on their contents. This is shown when they cease to receive blood from the heart; their tonicity then narrows their calibre, and thence they are always found empty after death. It also adapts them to different degrees of fulness, and yet maintains in their walls the tension that is favourable to equality in the motion of the blood. Tonicity performs an important part in the phenomena both of health and of disease.

It has been stated, that tonicity is quite distinct from irritability; and that, although irritable fibres possess tone, tonic textures are not irritable. This however is not true with regard to the arteries; for I have many times distinctly seen them *slowly* contract, and *remain* contracted, at a point to which an irritant,

(mechanical, chemical, or electrical,) has been applied. The discovery, by Henle, of a structure distinctly muscular in arteries, confirms this observation. I have, in like manner, satisfied myself of the irritability of the air-tubes, which move more rapidly under a stimulus than the arteries; the intestines do the same in a still higher degree, but still inferior to that of the œsophagus and voluntary muscles, the contractions of which, on the application of a stimulus, are abrupt, and immediately followed by relaxation. So far, then, it appears, that the slow contraction of tonicity is influenced by the same agents which excite irritability; but there is another agent, temperature, which seems to affect them differently, (§ 74, 75). Cold, which impairs irritability, increases tonicity.—Under the influence of cold, vessels generally, but especially arteries, shrink in size very remarkably;* and the muscles and other textures, under the same circumstances, present a firmness and vigour of tonic contraction, which impede the quickness of motion that characterizes the highest degrees of irritability. Under the influence of heat, on the other hand, muscles are more relaxed, and more irritable: the pulsations of the heart are made by it more frequent.

Cold and heat, therefore, become excellent tests of the presence of tonicity; and by their means it is found that this property is possessed by textures, which are not distinctly muscular; the veins and the cutis, which contract remarkably from cold, and are relaxed by heat,† are illustrations of this.

Now tonicity is a very important property in the animal economy; its presence in the normal state is very necessary for the preservation of health, and its abnormal modifications are concerned in causing and constituting disease, more particularly in the

* This fact must be familiar to every one who has noticed the difference of the pulse when a limb is cold and when it is warm. But I have seen it more forcibly illustrated by experiment. On plunging into cold water the aorta of an ass just dead, it contracted so closely as to obliterate its cavity; and it required some force to pass the little finger into it. The crimping of the flesh of fish is referable to the same principle.

† It is difficult to assign the limit between textures that are irritable and not irritable. Thus some large venous trunks, as the cava, have been found by Valentin to exhibit slight contractions on the sympathetic nerve being irritated; and fibres, like those of an unstriated muscle, have been found in their coats. The irritability of the dartos is well known; and I have frequently seen the skin of the trunk and limbs contract, and cause the projection of the papillæ (presenting the appearance of the cutis anserina), on gently scratching or tickling it, the appearance being confined to the vicinity of the part tickled.

vascular system. Practical men have long felt the existence of something of this kind, without being able to define or localise it; the terms tone and atony, bracing and relaxing, in such frequent use, are proofs of this. We proceed to notice some of the results of *excess* and *defect* of tone.

121. Where there is an *excess of tonicity*, the muscles are so firm that there is scarcely room for supple motion; the pulse is hard, and tense, and it may be frequent or slow, but in either case there is scarcely any interval between the heart's beat and the radial pulse. The capillary circulation is active, and the extremities warm; but owing to the tense state of the vessels and of the skin, the secreting organs do not act freely, the urine is high coloured, the bowels are disposed to be costive, and the skin to be dry and hot. The vascular system is in a state of such high pressure, that any weak part may give way, and induce local congestion or flux, active hæmorrhage or inflammation, apoplexy or gout; but there is less than usual proclivity to suffer from cold, endemic and infectious poisons, and other influences of a like depressing character. The causes which produce excessive tonicity are an over-nourishing and stimulating diet, with want of sufficient exercise; a dry bracing air; tonic medicines, such as iron and bark; the excitement of fever; and the occurrence of other disorders in which the blood becomes over-heated or over-stimulating from the presence in it of irritating matters, such as lithic or lactic acid, and other products of imperfect assimilation, or other results of defective depuration.

122. *Remedial measures.* — In such a state bloodletting and other evacuant measures serve to reduce the tension and excitement of the vascular system, but still the fibres may remain too much braced, and the pulse too hard, and the secretions defective; then the vessels soon fill again and the evil is renewed. The measures most likely to remove this morbid state of excessive tone are such as tend to relax the braced fibre, and increase the secretions, for instance warm bathing, exercise, the use of sudorifics, aperients, and diuretics, and a moderated diet. Some remedies, (antimony) seem to directly reduce the tone of the vascular fibre, and so act as relaxants. We shall have to advert to this subject again when speaking of inflammatory fever, in which excessive tone of the vascular system, is one essential condition.

123. Where tonicity *is defective*, the muscles are flabby and incapable of continued exertion, and sometimes they are too irritable, and affected with the tremulousness of debility (§ 113). The heart likewise is irritable, and exhausts its strength in palpitation; the pulse is soft and yielding; it is often full when slow, and sharp when frequent; but it is without firmness or endurance, and is easily accelerated. Another distinctive character of this condition is retardation of the ordinary wave of the pulsation, the interval between the heart's beat and distant pulses being increased; so that the radial pulse is often felt after the second sound of the heart is heard (§ 121); the pulse wave is slower than usual (§ 120), because the vascular tubes are less tense. Sometimes the absence of that tightening of the walls of the arteries whereby the internal movement is ordinarily controlled, permits their mechanical elasticity to come into play; and this reacting after each stroke of the heart gives that peculiar reduplication or rebounding of the pulse, which has long been described under the term *dichrotous*. This is often observed in convalescence from fevers, and other analogous diseases after the subsidence of vascular excitement; the state of excessive tone being followed by one of consequent atony. (121.)* A loose relaxed state of the vessels renders the circulation in distant parts weak, so that the extremities become cold, whilst the head and internal organs are congested. Sudden exertion or change of posture may under such circumstances so disturb the circulation as to cause faintness or giddiness. Want of tone in the stomach and intestines favors indigestion and costiveness, and causes these organs to become distended with wind and accumulating fæces. From the secreting organs being irregularly supplied with blood, the secretions are also liable to get disordered, and to be either scanty and depraved, or profuse and watery.

It is quite obvious that a person in such a condition of relaxation must be prone to various diseases. He has very little power (§ 85) to resist malaria, infection, or other depressing influences. If he is exposed to cold, the blood is readily driven through the weak vessels into the interior (§ 79), and there causes congestion

* One very important effect of hyper-tony of the vascular system is the rendering it intolerant of some medicines. Thus it is frequently found that patients, otherwise weak, do not bear tonics well because the vessels are more or less already in an excited state from the presence of gouty or rheumatic matter in the blood. Then so soon as this matter is expelled tonics are easily borne, and render good service.

or inflammation. The debilitated intestines have no power to expel offending matter from them (§ 57). The system, in this state of atony is in many respects on the verge of disorder, especially congestion and its consequences, and other derangements of the circulation, as well as being particularly predisposed to suffer from all the various exciting causes of disease.

The causes of loss of tone are various debilitating influences (§ 28, et seq.), such as continued and exhausting excitement of the vascular system (§ 64), continued exposure to heat, especially if with moisture, confinement in impure air, defective nutrition (§ 63), imperfect excretion (§ 68), &c. Muscles lose their tone from want of exercise, and bloodvessels theirs from the long-continued operation of cold (§ 77). The tonicity of the arteries is remarkably influenced by the state of the nervous system; we shall hereafter find that a relaxation of the arteries of the part is the chief cause of local determinations of blood.

124. *Remedial measures.* — The proper remedies for defective tonicity are tonics, that is agents which tend to increase the tone of the whole system (§ 120), but particularly that of its muscular and vascular structures. It has already been stated that cold has this effect in a marked degree (§ 30), and in truth, cold, properly applied, is one of the best tonics which we possess. But to effect this purpose its application should be sudden and not sufficiently continued to cause depression or any other morbid effect. The shower-bath and plunge-bath are the most effectual forms in which it can be used; and free sponging, with cold salt water, is suitable even for weak subjects. Free exposure to a pure bracing air, and moderate exercise taken at the same time, have also marked tonic effects. There are many medicinal tonics, the most effectual of which are bark and its preparations, such as quinine, cinchonine, bebeerine, and salicine; also preparations of iron, arsenic, zinc, copper, and the mineral acids. Generous living has itself a tonic influence, in so far as it tends to enrich the blood, which sustains tonicity as well as all other vital properties.*

* It appears to me highly probable that the efficacy of tonics and antiperiodics in intermittent, remittent, and typhoid fevers, as well as in neuralgia and other disorders, in which internal congestion without inflammation is present as an element, may be ascribed to the property that is implied in their name,—that of restoring deficient tone to the vascular system. At an early period in these diseases, before the functions have become much disordered, or the blood very much depraved, a few large doses of quinine often succeed in effecting a cure. The power which this remedy possesses to remove congestion

SECTION III.

ELEMENTARY NERVOUS FUNCTIONS.

125. The functions of the nervous system are now generally resolved into—1, those of the *nervous centres*, parts which generate and combine nervous influence and force, and 2, those of the *nerve trunks and branches*, parts which conduct this influence or force to or from the positions in the body, in which the agency is required. The functions of the nerves are also further distinguishable as being of the nature, either of *sensation—voluntary motion—involuntary motion*—or *sympathy*.

It is difficult to separate these primary elements of function concerned in the production of disease from the complex combinations in which they generally are presented in the phenomena of animal life, and which in strict accuracy should be treated of under the denomination, either of proximate elements of disease, or of special disorders of the nervous system. In order to avoid the need of future repetition, an outline is, however, here introduced of the most elementary functions of the nervous system, and of such of their proximate combinations, as, acting in *excess*, in *deficiency*, or in *perversion*, may become influential in the production of morbid deviations from the standard of health.

It may be premised that every nervous function is susceptible of certain variations, in accordance with changed conditions of structure. Of these some are ascertained, and serve to illustrate aptly certain important points in pathology and therapeutics.

appears to be closely connected with its curative agency. In more advanced stages of these diseases, when the disorder has become inveterate, and the depraved secretions and altered blood indicate that there is something beyond mere want of vascular tone, the efficacy of quinine is very much less; it may even aggravate the symptoms if continued febrile action have intervened. Eliminants,—agents that augment the excretions, and through them carry off the offending effete matter, then need to be premised; or they may be given with tonics, whose operation may be expected to be beneficial, although not in the same rapid and decided way, as when vascular atony is the sole ingredient of disease. The congested state of the blood-vessels after the subsidence of neuralgic pain, or even of inflammation, is another condition in which the speedy and satisfactory action of tonics may be looked for. I have often had occasion to notice that certain paroxysmal nervous diseases like epilepsy, chorea, hysteria, cardiac palpitation and asthma, are associated with an atonic state of the vascular system, for which tonics are the best remedies. As an empirical fact, this is fully recognised, but the obvious explanation has not always been kept in view.

These nervous functions, in common with all others, are excited by increased flow of blood through the tissues that are their seat; and they are depressed by its diminished flow, or by its stagnation in the vessels. But these functions depend, not only on the quantity and continued motion of the blood, but also on its quality; hence they are liable to be influenced by whatever alters the composition of the blood, for instance, the retention of excrementitious matters (§ 68) the presence of poisons (§§ 56—72—73—82—105) the predominance of chemical affinities beyond what is salutary for the wear and renovation of the tissues (§ 53) as when a septic or putrescent tendency exists in the body.—But in addition to these causes of nervous derangement, acting through the circulation (which are of the most frequent occurrence), there are others to be mentioned, which operate more directly upon the nervous structure itself; of this nature are mechanical irritation, heat, cold, electricity, and mental emotion.—Mechanical irritation, applied either to a nervous centre, or to a nervous branch, excites its function, but in consequence of the high mobility of the structure concerned, this excitation is very apt to extend from one part to another of the nervous system.—Very severe mechanical injury acts, too, like a universal shock, depressing or suspending the vital functions, not only of the parts injured, but also of other portions of the nervous and muscular apparatus.—Heat, within moderate limits, acts by exciting nervous power; and cold has the opposite effect, and although a portion of the influence of these agents must be due to their operation on the circulation, it seems probable that there must also be some more direct effect, for a certain degree of warmth is essential to the maintenance of all the vital properties.—Intense electricity is a powerful excitant of the nervous functions, especially of the motor ones: somewhat of an opposite effect is, on the other hand, produced by atmospheric electricity, which often depresses nervous energy in a very remarkable degree.—Similar opposite influences may be observed in the action of mental states on the nervous system.

Under whatsoever circumstances the nervous function is excited, its operation is attended with an expenditure or decay of nerve-substance, (as we found to be the case with respect to muscular action) (§ 111), and the results of this expenditure are conveyed through the blood to be excreted by the kidneys. Hence under great nervous excitement there is an increase of the phosphates in

the urine, derived from the oxidation of the phosphorized fat of nervous matter.

SENSIBILITY.—*Centric.*

126. The term *centric sensibility* may be applied to the functions of the posterior columns of the spinal marrow, the corpora restiformia, and other parts of the nervous centres most directly concerned in sensation; but as these structures are also the sources of the sensibility of other parts of the body, their influences may be extended, and become more or less general throughout the system, and thus disorders of centric sensibility may also be disorders of *general* sensibility, while modifications of *local* sensibility are more usually connected with the functions of individual nerves.

Diseases of centric sensibility may consist of either—1, *excess*; 2, *deficiency*; or 3, *perversion.*

(1.) *Excessive sensibility* is more or less present, when the nervous centres are excited in the early stage of inflammation or of determination of blood in the head or spine; where there is intolerance of light, noise, and motion. A similar condition exists in hydrophobia and tetanus, from mere irritation without inflammation, and in the early stage of many febrile disturbances of the synocha class, in which there is quickened circulation without any stupefying influence. But sensibility is also excessive in some persons, either congenitally (§ 41), or as a consequence of disease (§ 31, 34). Such persons are commonly called nervous; they are worried with trifles; startled at shadows; distracted by noise or bustle; never free from some ache or pain; almost every feeling is suffering; what in others would be slight pain, in them amounts to agony. Hence they are perpetual invalids, quite unfit for the rugged path of life, over which they walk, as it were, barefooted and thin-skinned. If real disease attack them, its nervous symptoms are so much exaggerated, that a medical attendant is apt to fall into the error of either ascribing all to "the nerves," or of estimating the disease by the severity of the symptoms. This over sensibility is generally conjoined with excess of irritability, and want of tone (§ 113, 123). Other nervous functions, such as sympathy and reflex action, are also often excited, or in disorder. The symptoms connected with sensation most frequently present are neuralgic pains of various parts, excessive sensibility of the

surface, headache, pain in the back or left side, and spinal tenderness.

127. The pathological cause of increased general sensibility is probably excitement, either from the slighter influence of the same cause which acts in the early stage of encephalitis, namely an excessive supply of blood to the posterior columns of the spinal marrow, the corpora restiformia, and the parts of the cerebral mass concerned in sensation, or from some other irritation more directly applied to these parts. Local determination of blood may be the result of original development; or it may be the consequence of inflammatory affections of the encephalon, of undue mental exertion or moral emotion, of irregularities in the menstrual functions, or of the reaction ensuing after great losses of blood; all of which states are known to be the occasional precursors of morbid sensibility. On a future occasion, when treating of the subject of irregular distribution of blood, we shall endeavour to point out why great losses of this liquid, and other causes of sudden weakness, are liable to be followed by excessive sensibility. The extreme refinements and luxurious habits of the upper classes, involving more excitement for the mind than exercise for the body, and for the feelings than for the understanding, are well calculated to foster this over sensitive state. The female sex is proverbially more sensitive than the male, and this appears to be due, not only to original conformation, but also to sedentary and enervating habits, and the want of the invigorating exercise and fresh air which give robustness to the frame.

128. *Remedial measures.*—The medicinal influences most directly opposed to excessive general sensibility are narcotics or anodynes, such as opium, henbane, hemlock, Indian hemp, belladonna, chloroform, and ether, administered internally, or, in some instances, applied externally, as when a soluble salt of morphia is sprinkled on the skin deprived of its cuticle by a blister. All these agents diminish nervous sensibility; and, in proportion as this is exalted (§ 126), the system generally bears larger doses. But where the increased sensibility depends on inflammation, or vascular excitement of the nervous centres (§ 127), the more fitting treatment is obviously that which will be hereafter described as antiphlogistic.* Again: where the excessive sensibility arises from

* Cases of generally increased sensibility, having some resemblance to cerebral or spinal meningitis, occur not uncommonly, and are known by the name of spinal irritation.

the nervous excitement of irregular circulation, from general weakness (§ 116) and from loss of tone, (by no means an uncommon combination,) tonics (especially the metallic) (124) and stimulants (119), with or without narcotics, are the proper remedies.* Weakness, softness, and slow transmission of the arterial pulse (123), and absence of fever or permanent heat of skin, are the chief symptoms of such a condition. In this state stimulants act speedily, and tonics more slowly, but more enduringly, by equalizing and invigorating the general circulation, and thus relieving the nervous centres. But country air and exercise, cold or tepid bathing, especially in the mode of the shower bath, plain food for both mind and body, early hours, and an avoidance of all enervating habits, are often more conducive to the cure than medicines.

An anodyne influence more powerful in degree, than that exercised by any other agent, although but transient in duration, is that resulting from the inhalation of the vapour of chloroform or of sulphuric ether, which has during the last few years been extensively introduced into practice with a view to render the body insensible to the pain of parturition, of surgical operation, or of disease. These agents, and nitrous oxide gas (which has a similar effect when used in the same way,) act on the sensorium, rather than merely on the sensitive nerves. In most instances, if the inhalation be continued for a sufficient time, it induces complete insensibility to pain. In many cases, however, and especially where the inhalation has been less prolonged, or where the air has been less impregnated with the anodyne vapour, sensibility is blunted, but not destroyed, and the patient makes movements and utters expressions indicative of slight pain, but has no recollection of it when restored to consciousness. The memory seems to be

These present a great diversity of symptoms, more or less of an hysterical character, but one almost constant sign is excessive sensibility of the surface, which is most intense near the spines of some or other of the vertebræ. In my experience this affection is not permanently benefitted by antiphlogistic treatment, but rather by mild tonics, and locally soothing the irritated spine by means of topical narcotic applications, tepid or cold sponging, or sometimes even douche baths.

* Periodical attacks of pain frequently yield to the free exhibition of quinine and other antiperiodic and tonic remedies; but during the paroxysm narcotics not only give temporary relief, but by reducing the general sensibility prepare the system to bear tonics, and thus expedite the ultimate cure, provided they do not arrest the secretions. Its tendency to diminish all secretion is the chief objection to the employment of opium, which is therefore commonly combined with evacuant remedies, to obviate this mischievous result. Thus combinations of opium or morphia with mercury, antimony, ipecacuanha, colchicum, and salines, often agree better than the narcotic in its simple state.

more affected than the perceptive function. The power of voluntary motion is suspended in about the same ratio as sensibility; but the insensible reflex motions of the eyelids, of breathing, &c., are modified, but not abolished, unless the inhalation be continued so long as to induce complete asphyxia.

The operation of these vapours is obviously of a narcotic kind, like that of opium and alcohol; but is more speedy and transient, because it passes freely and directly through the lungs into the arterial blood, and so affects the brain, and because it is as promptly dispersed from the blood and lungs when fresh air only is breathed. It has been maintained by many, that these anæsthetic inhalations operate only by interference with the respiration, inducing a degree of asphyxia; but so far is this from being the case, that their best effects are produced when the respiration is steadily maintained; and I believe that the great end to be aimed at in the administration of chloroform, is to narcotise, as far as possible, without too much embarrassing the breathing. This it is difficult to accomplish without a freer supply of oxygen than atmospheric air contains; and I should hence expect safer and more satisfactory results from the inhalation of a mixture of chloroform or ether vapour with oxygen gas, which might be continued with safety for a much longer period than a mixture of vapour and air.* Since the anæsthetic properties of chloroform were discovered and applied by Professor Simpson, the use of this agent has in a great measure superseded that of ether vapour, being more manageable and agreeable, when inhaled, and more potent in its stupifying powers. There is, however, one peculiarity of its physiological influence, which, while recommending its employment in some instances, renders it highly hazardous in other cases.—It often weakens the action of the heart, and has induced fatal syncope, where there was fatty degeneration of the organ. Whenever there is great exhaustion of the heart's power, and especially if there is also suspicion of the presence of degeneration, or other extensive organic disease, chloroform is a less eligible anæsthetic than ether, which is more stimulant. In all cases where the stupefying action is needed to be maintained for a considerable length of time,

* Since this suggestion was first made, Dr. Abraham of New York has succeeded in restoring a patient who was asphyxiated and pulseless under the influence of chloroform, by the employment of artificial respiration with oxygen gas.—*Canada Medical Journal*, Jan., 1853.

much circumspection should be used; the state of the pulse should be carefully noted, and the inhalation be immediately suspended so soon as insensibility to pain is induced.

Although the chief influence of chloroform inhalation is transient, yet in consequence of its saving the nervous system from the shock of intense temporary pain during a paroxysm of suffering, it often prevents that consequent nervous irritation and exhaustion, which is highly injurious to the vital powers, and which predisposes to a return of the painful attack. In neuralgic and painful spasmodic affections, chloroform not only is a valuable agent, in so far as it procures temporary relief, but also because by the removal of one of the paroxysms it may break the habit of diseased action, and so effect a permanent cure.

129. (2.) *Deficient* centric or general sensibility is exemplified in its extreme degree in the coma, induced when the circulation in the sensitive centre of the nervous system is impeded by pressure, congestion, or other obstruction * (§ 52), or in the stupor caused by narcotic influence. Thus when a person is in a fit of apoplexy, or poisoned by opium, he has lost all feeling, as well as power of voluntary motion. If the blood becomes impure by the retention of excrementitious matter, as on suppression of urine, a like stupor occurs (§ 68). *Anæsthesia*—that is loss of sensation—very rarely exists without loss of motor power. But short of these degrees, there are persons who congenitally (§ 44), from disease (§ 31, 34), or from age (§ 48), are somewhat *deficient* in sensibility—feel less than other folk. All their feelings are obtuse and their actions slow; they have neither intense suffering, nor intense pleasure. Such persons have also little irritability, but much tone of fibre, and they are remarkable for their immunity from many diseases. But they are the more liable to others, such as fulness of blood, apoplexy, gout, costiveness, and the various evils which these may bring. There is one highly important difference between them and the over-sensitive:—disease when it occurs, may in them be

* Dr. Fleming has produced somnolence and temporary insensibility by pressure on the carotids in the neck, and he thinks that this expedient might be resorted to for the purpose of preventing or relieving pain (*Brit. and For. Med. Chir. Rev.* April, 1855). I have some doubts whether the amount of pressure required to arrest the flow in the carotids, may not have injurious results, both on the vessels themselves and on the circulation in the brain afterwards; but the experiment is most instructive in its relation to sleep and coma.

latent, advance far, and become even dangerous before it is felt; and may imperceptibly increase until it is incurable, or until sudden death ensues.

130. *Remedial measures.*—When obtuseness of feeling arises from fulness, obstruction, or pressure of blood in the nervous centres, the treatment should consist in attempts to remove these states by depletion, derivation, and other means to be hereafter mentioned under the head of disordered circulation. Where there is no actual disease present, but merely a torpor of the sensitive function, mental excitement, bodily exertion, dashing with cold water, vigorous friction, and the application of strong stimulants or excitants to the skin, are the best means of arousing the nervous system from its state of lethargy. The insensibility produced by narcotics, and retained excrementitious matters, should be combated by measures calculated to eliminate the stupifying matter through the natural outlets, as, for instance, the administration of purgatives, diuretics, emetics, &c. It is remarkable how promptly drastic purgatives sometimes effect the restoration of sensibility, in stupor resulting from imperfect action of the kidneys. Hysterical stupor yields as readily to the influence of turpentine or assafœtida enemata. It is doubtful whether we have any medicine capable of directly increasing sensibility. Strong tea and coffee perhaps have the best claim to such a property. What effect would arise from electrifying the spine and occiput? Stupor and impaired sensibility sometimes occur in a state of anæmia; this is seen in cerebral syncope, and in children or females who have lost much blood, and is immediately caused by stagnation of the blood in the brain. Under such circumstances, the pallor of the skin and weakness of pulse indicate that stimulants afford the best chance of restoring sensibility.

131. (3.) *Perverted* centric, or general sensibility is often manifested by persons in whom there is also increased sensibility (§ 126); its character is presented in the peculiarity of the sensations which are experienced. Thus feelings of tingling, prickly heat, trickling cold, in various parts; of a lump in the throat, a hot ball in the side, a fluttering at the stomach, and illusions of the special senses, severally and variously affect persons whose sensibility is modified more in kind than in degree. Such patients may also have a depraved appetite, craving for sour

things, cinders, mortar, and all manner of filth. These symptoms generally occur in females, often in connexion with irregular menstruation, and therefore are called hysterical; but their pathological cause must be sought in the nervous system, the functions of which become deranged, probably from irregular supply or bad quality of the blood supplied to them. The *remedial measures* indicated for this condition are therefore such as are calculated to remove this cause: chalybeates and other tonics, pure air, nourishing food, and all influences which improve the quality, and equalize the distribution of the blood. Narcotics and sedatives may be useful as temporary palliatives. In rare cases, the general sensibility is perverted in consequence of structural change in the nervous centres, as for instance in softening of the brain; strange and distressing sensations are then experienced in every part of the body.

DISEASES OF LOCAL SENSIBILITY.

132. The sensibility of every portion of the body depends upon its structures preserving their due relations with the nervous centres by means of the nerves. In some instances change of state in those centres themselves modifies the sensibility of the parts that are furnished therefrom; this is instanced in cases of local pain or local anæsthesia attending on limited lesions of the brain. More commonly, however, alterations in the sensibility of parts depend on the condition of the conducting nerves which are media of communication between those parts and the nervous centres.

The feeling of a part affected in this way may be *excessive*, *deficient*, or *perverted*. This may be illustrated by experiment. By irritating or striking a nerve, pain is produced in the part to which it is distributed, and the sensibility of the part remains exalted—that is, it feels tender or painful afterwards. By pressing on the nerve, a new and perverted sensation of tingling, pricking, and numbness, is caused. By pressing more strongly, or dividing the nerve, the feeling is further impaired or altogether destroyed. Similar effects may be produced by a tumour, ligature, effusion, or other cause pressing on a nerve in its course. Disease of the nerve, or of a part of the spinal or cerebral structure connected with it, may likewise modify the sensation of parts. Thus inflammation of the sheath of the ischiadic, or trifacial, nerve may cause, first neuralgic pain, and afterwards numbness in the parts to which the

nerve is distributed. There are other painful affections which are to be considered and treated as cases of exalted sensibility; such are the (as Dr. Billing observes, erroneously so called) irritable breast, testicle, uterus, &c.

133. But the function of sensation depends on the due supply of blood to the extremities, as well as to the trunk and origin of the nerves. Hence if blood does not circulate freely through a limb, the sensations are impaired; and if it passes too freely, the sensibility is exalted, and there may be itching, tenderness, or even pain. In organs of special sensation, the senses are modified, together with the common feeling: thus in disease of the optic nerve or retina, there are intolerance of light, perception of specks, (*muscæ volitantes*), clouded vision, or even blindness; in diseases of the ear, ringing and beating noises, or deafness, — as well as itching, tenderness, and pain, which are modifications of common sensation.

134. At the external orifices of the body, and in the linings of its interior passages, there are peculiar kinds of sensibility connected with the functions of ingestion and egestion; modifications of these become elements of disease. As examples of excessive sensibility in such may be enumerated thirst, craving, nausea, tenesmus, and urgent micturition: of impaired sensibility, anorexia, and loss of feeling in the rectum and urethra.

135. In considering internal parts, we have only to notice sensibility *exalted* by disease. We do not know that they naturally possess any feeling. We are not at all conscious of such ordinary processes, as the passage of food and fæces in the alimentary canal, of the movements of the lungs, of the heart, or of the blood through the vessels; but under the influence of disease we become painfully sensible of several of these motions. Thus excessive sensibility is developed by inflammation, as shown in pleurisy, peritonitis, meningitis, &c., or by irritation of a mechanical or other nature, as evinced in colic, biliary and urinary calculi, gastralgia, and perforation of the stomach or intestines, &c. It is very remarkable that pain, which is perhaps severer than any other, should arise so suddenly in parts which give no evidence of common feeling. Numerous other morbid sensations arise in connexion with nervous disorder of internal organs; thus dyspeptic and hypochondriacal patients describe extraordinary feelings of heat, cold, weight, dragging, sinking, &c., in the abdomen, chest, and

head, which seem to be the result of exalted and perverted nervous sensibility.

136. In many instances we have to regard pain, merely as a symptom, which is only to be removed by means tending to remove the cause, that is the lesion which produces it (§ 132, 133); but in many cases, on the other hand, pain, although a symptom, is an important element in the disease itself, and one against which remedies must be expressly directed. This it is, in neuralgia, gastralgia, nephralgia, colic, dysmenorrhœa, and perforated intestine. So long as the excessive pain lasts, all the functions suffer (§ 66), faintness and exhaustion are apt to ensue, and if no relief comes, the prostration may be fatal. Here, to mitigate or remove the pain is a first and pressing indication. Again: in some other cases where the pain is less severe, it may be very hurtful by interfering with important functions. Thus the stitch of pleurisy impedes the breathing: the pain of tenesmus, and irritation of the stomach or windpipe, cause such distressing efforts at straining, vomiting, and coughing, that the vital functions are thereby kept in a state of disturbance, until the strength is exhausted. Here it is necessary promptly to direct the treatment towards the pain on account of its immediately pernicious effects.

137. *Remedial measures.*—When excessive sensibility depends on inflammation, antiphlogistic measures will be those most calculated to remove it. Where it lingers after the inflammation, is more than it can account for, or is independent of it, then anodynes become the chief remedy. The most powerful of these is the vapour of chloroform or ether inhaled as above noticed (§ 128), or externally applied; in either way it often serves for the mitigation or removal of local pain of a temporary character. If the case admit of the direct application of chloroform to the seat of pain, as when the skin or other superficial texture is affected, the chloroform may be applied on a piece of cotton or flannel covered by the hand, or by oil silk; or it may be rubbed in as a liniment mixed with an equal quantity of almond oil. Professor Simpson (to whom we owe the discovery of the anæsthetic power of chloroform) has recently found carbonic acid gas to be a very efficient local anodyne in cases of uterine neuralgia. He considers that the utility of the natural douches at Ems in painful uterine complaints may partly depend on the quantity of carbonic acid which they contain. The power of effervescing draughts and carbonated waters in relieving sickness

may fairly be ascribed to this property of the gaseous acid; which is probably also what reconciles the stomach to the copious draughts of many kinds of mineral waters which would scarcely be tolerable without it. Perhaps the soothing influences of the yeast poultice may be ascribed to the same ingredient. As carbonic acid gas is readily procured, its application deserves further trials.

The most potent of the fixed anodynes are opium and its active principles; but these possess certain injurious influences (they arrest the secretions) (§ 70), which sometimes render them less eligible than the weaker narcotics, hemlock, henbane, stramonium, belladonna, and Indian hemp. The stronger preparations of aconite, and its alcaloid, and tobacco, are powerful anodynes, and are very valuable as outward applications; but their depressing operation on the heart renders them unsafe for internal exhibition unless under very careful superintendence. One of the most effectual methods with which I am acquainted, for relieving severe local pain, is the endermic application of morphia; for this purpose a blister is applied to the painful part, and when it has fully risen, the cuticle is completely removed, and the denuded surface sprinkled with from half a grain to two grains of a soluble salt of morphia (the acetate or hydrochlorate) in fine powder; this may be repeated once or twice daily, according to the urgency of the pain. After the first irritation resulting from the application, the effect is anodyne, and then narcotic on the system, and less of the consequent injurious effects follows than when opiates are given by the mouth. The application loses all power, so soon as the blistered surface becomes dry. Counter-irritation and warmth also serve to relieve pain. The pain of gastrodynia may often be removed by applying a sinapism to the pit of the stomach—that of colic and dysmenorrhœa by hot fomentations, or bags of hot sand or salt, &c. Benumbing cold, produced by the application of a freezing mixture (pounded ice and salt) to painful parts is recommended by Dr. James Arnott as a very efficacious anæsthetic, and the plan seems to have answered in his hands; but great care should be taken lest the living structures and vital functions be injured through congestion or obstructed circulation induced by this means. In some cases, painful feelings are removed by making such pressure on the part as serves to counteract tension, and diminish, without stopping, the flow of blood through it. Painful affections occurring with a weak circulation, particularly

if intermittent in their attacks, are often removed by tonics: thus neuralgia is successfully treated with quinine and iron, and hemicrania with quinine, bebeerine, or liquor arsenicalis.

138. We are not possessed of equally efficacious means of restoring lost sensibility. Stimulant applications and frictions are serviceable where the defect arises from deficiency of circulation in the part; and tonics, especially of the chalybeate kind, are useful where there is an insufficient supply of good blood to the nervous centres and nerves. I have recently employed an acid phosphate of iron with advantage in such cases. Strychnia or cantharides given internally, and electricity used topically, may *perhaps* have some little effect in exciting the functions of the dormant nerves, but they certainly affect the motor functions more than the sensory.

SECTION IV.

DISEASED VOLUNTARY MOTION.

139. The functions of certain portions of the nervous apparatus, by which they convey the impulses of the will to the voluntary muscles, may become disordered, and may so constitute an element of disease. Some of these disordered manifestations have already been noticed under the head of diseased irritability (§ 113); and it was there observed that the fault is more commonly in the nervous influence which excites the muscles, than in the condition of the muscles themselves. This is the case in most convulsive diseases, and in those cases of paralysis which depend on injuries of the voluntary nerves, or of those parts of the spinal and cerebral system which are the channels of volition. A brief illustration of these affections may be given in a form corresponding with what has been said of the disorders of sensation. As in the case of diseased sensibility, so disordered motor power may depend on the condition of the nervous centres which originate that power, or on that of the nerve-trunks and branches which convey it to the muscles. The first class comprises disorders of *centric* or *general* volition; the latter disorders of *local* manifestations of the power.

DISEASES OF GENERAL OR CENTRIC VOLUNTARY POWER.

140. The voluntary motor power may be said to be *generally in excess,* when the brain is excited by strong emotions or feelings (§ 66), by stimulating liquors (§ 56), and by the hurried circulation of phrensy or phrenitic delirium. Hysteria, which constitutes in itself a microcosm of all the nervous disorders, furnishes analogous examples. The strength and rapidity of movement displayed in hysterical cases are sometimes astonishing; yet such movements are obviously voluntary, for they are often performed rhythmically, or to a tune, as in dancing. The dancing of tarantulism, and the extravagant exertions of the fanatics called Jumpers, probably arise from an erethism of the part of the nervous system concerned in the production of voluntary motion. A naturally high voluntary power, yet short of disease, is evinced in the energetic and active movements of persons, who excel and delight in feats of strength or agility. Mere muscular strength will not suffice without nervous energy to act on it. Most individuals, when in the vigour of health are conscious of an energy, which at times prompts them to active exertion, and which is very like an overflow of voluntary motor power. A morbid excess of the same is commonly exhibited in those fidgetty persons who are constantly in motion, and to whom a state of rest is almost an impossibility.

141. *General volition* is more or less *deficient* in apoplectic coma, stupor from pressure, congestion, and other causes; intoxication from opium, alcohol, and other narcotics, where other nervous properties are also impaired (§ 129); in trance, catalepsy, and nightmare; in a less degree also in cases of lethargy and of weakness from over-exertion (§ 68). This defect may be sometimes suddenly induced by terror, surprise, &c. (§ 69), which for a time take away the power of motion. Hence the fable of the power of the Gorgon's head; and the signification of the expressions, *petrified with astonishment, motionless with terror, fascinated,* and the like. The muscular power (§ 110) is not lost in these cases, but only the influence of the mind over it—that is, volition. Slight degrees of this lowered state of volition are instanced in those periods of languor which visit individuals suffering from indigestion, or during an oppressive condition of the atmosphere. Extreme weakness of a portion, or the whole, of the body is sometimes exhibited in a class of hysterical patients, in whom it is difficult to say whether the want of power, which approaches to

paralysis, is in the muscles or in the voluntary nerves. The powers of the voice and of the lower extremities are the most prone to fail, but there is commonly also great loss of vigour in other parts of the body; and as the inability or indisposition to exertion may last for months, or even for years, the muscles will waste for want of use unless their nutrition be promoted by electricity, friction, and other like agencies that promote the circulation. The sudden loss, and as speedy recovery, of motor power, which has occurred in some of these cases, in some instances obviously from mental influence, inclines me to rank them among instances of defective volition.

142. Examples of *perverted voluntary power* are afforded in chorea, delirium tremens, mercurial tremor, shaking palsy, and some analogous affections called hysterical. In these volition may also be defective (§ 141), but it is not always so; sometimes it is even more energetic than usual; but each act of the will is perverted in its performance, and when it sets muscles in motion, they are the wrong muscles, or too many are moved, or too forcibly, or irregularly, so that the resulting action is not in accordance with the will. This morbid state is also exemplified in the persons of many who are called nervous, and whose voluntary movements are performed with undue precipitation and trepidation. The pathological cause of these irregular excitements of the nerve-force, probably lies in the relations that connect the motor ganglia and nerves, and the blood which sustains their function and nutrition: a deficient supply and depraved quality of the blood especially induces the morbid excitement, instead of sustaining the normal function.

PARTIALLY DISEASED VOLUNTARY POWER.

143. We can scarcely point out examples of partial *excess* of *voluntary* motion. The convulsive movements of voluntary muscles are quite involuntary actions, and have been already noticed under the head of diseased irritability (§ 113); but it was there mentioned that they may arise from irritation of the nerves, independent of the influence of the will. Hysteria does, however, furnish examples of excessive movements of one limb, or part, of the body, so far amenable to mental influence as to be excited and timed by ideas in the patient's mind. These cannot be said to be wholly involuntary; but are the results of a wilful impulse, perhaps too strong to be *easily* resisted. Something bordering on

the same thing is also exhibited in certain habitual movements or *tricks* to which some persons are addicted, and which although really voluntary, become, through indulgence, spontaneous and constant, to the great annoyance, both of performer and observers, and then require a great exertion of self-constraint for their control.

144. *Partial deficiency* of voluntary motor power is very common, and, like local deficiency of sensibility, may be traced either to partial disease of the motor (anterior) columns of the medulla and their prolongations;—to disease of, or pressure on, a motor nerve in its course;—or to a disordered condition of the ultimate distribution of the nerve, or of the circulation supporting its function. Thus paralysis of voluntary motion in an extremity or a whole side (hemiplegia), may arise from disease in the optic thalamus or corpus striatum of the opposite side: these being the channels of communication between the cortical seat of the sensorial functions and will, and the motory columns and nerves. Lesions of the motory (anterior) columns within the spine may intercept more or less the voluntary motor power of those parts supplied with spinal nerves from below the diseased point. Thus a lesion in the lower cervical portion may paralyse the upper and lower extremities and whole trunk, (except the diaphragm, which is supplied by the phrenic nerve): but a lesion in the dorsal or lumbar portion paralyses only the lower half of the body (paraplegia), or lower extremities. The mischief may, however, be more partial, paralysing one nerve only, as, the portio dura, causing distortion of the features; or the ninth nerve, causing difficult articulation, &c. The lesion of the nervous textures here alluded to may be structural change, such as tumours, effusions, or hæmorrhage, or it may only be an altered state of the blood-vessels of the part. In all these instances either the structure is injured, or the blood is prevented from duly supplying it with healthy nourishment. Another occasional cause of partial paralysis, is the presence of poison in the blood or in the nervous tissue, as in the case of lead palsy. Severe cold, or continued pressure, will impair voluntary motor power in a limb, by checking the free flow of blood, which is essential to the maintenance of the proper function of the nerves as well as of the muscles. Hysteria affords numerous examples of impairment of volition in parts, as in loss of voice and power of articulation, retention of urine, para-

lysis of limbs, &c.; these affections often come on quite suddenly, and may as suddenly cease.

145. *Remedial measures.* — *Excessive* voluntary power, as an element of disease, rarely calls for separate treatment. Where it occurs as a portion of the excitement of the nervous centres, it may be reduced by sedative influences of different kinds—depletion, antimonials, and cold to the head, being the most effectual where the excitement is attended with determination of blood; morphia, codeia, and other narcotics, where the excitement is more purely nervous. Inhalation of chloroform is as effectual in depressing the functions of the motor, as it is those of the sensory portion of the nervous system; but as it has a tendency to cause some congestion in the nervous centres, it is not a safe measure when there is any sign of vascular fulness or excitement.* There are several milder narcotics which often prove useful in calming nervous excitement, and in tranquillizing the inordinate movements to which that leads—such are henbane, lettuce, sumbul, camphor, and valerian. These are all very safe medicines, but apt to lose their powers very soon upon repetition. The violent exertions of maniacs are often wonderfully controlled by the application of the cold douche to the head, by the administration of nauseating doses of tartar emetic, and by the vertiginous effects of swinging. The vehement movements of persons affected by fanaticism and tarantulism commonly end in exhaustion; they might probably soon be checked by a timely ducking with cold water, a remedy so often successful in hysteria.

In all these different remedial measures, addressed to excessive motor nerve-force, three modes of action may be traced:—1. A sedative influence exercised on the circulation of blood which supplies the nervous centres or branches.—2. A sedative influence exerted directly on the nervous functions.—3. An indirect sedative influence coming in the form of exhaustion after continued excitement. The latter influence is mostly of use in preventing convulsive affections that result from superabundant motor power: habitual and regulated exercise proves efficient in this way, by expending the superfluous force. In fact hysterical convulsions of

* I learn however from Professor Simpson that he has used chloroform inhalation for many hours in infantile convulsions, with no other than a composing effect. In one instance a child was kept more or less under the influence of chloroform for three days, to remove recurrent convulsions, and ultimately recovered.

the ordinary kind seem to be a natural expedient for the discharge of pent-up accumulated force, and although they become injurious from frequent repetition, they are often productive of relief to the system at the time.

146. The treatment of *deficient* voluntary power consists in means calculated to excite the nervous centres, either directly, or through the medium of the circulation. Agents which restore free circulation of healthy blood through the nervous centres and the nerve-branches generally, increase voluntary power. Thus a stimulant draught raises the failing strength of a fainting person. By warmth and friction, one who is benumbed with cold recovers the use of his limbs. Sleep, or rest, restores voluntary power exhausted by fatigue. Sudden and powerful mental excitement, as from a fright, has been known to recal voluntary power which had long been lost. A lady who for several years had lost the use of her lower extremities, was startled by a rat running near her; having an extreme antipathy to the animal, she made an effort, and sprang upon a table near; the power, however, did not remain, for she could not get down again. More permanent cures of this kind have been effected by the excitement of religious fanaticism, as in the cases of the supposed miracles of Prince Hohenlohe, Miss Fancourt, &c. As we have seen that mental excitement sometimes causes excessive voluntary motion in healthy persons (§ 140), so we perceive that, suddenly applied, it may restore the power of effecting it where this is deficient. Thus the dread of branding by a hot iron, of the application of a large blister, or even of a douche bath, has sometimes cured hysterical palsy; and a sudden emotion of surprise has been known to restore a lost voice.

But in some cases volition is defective in consequence of pressure on, or congestion in, the brain, which then prevents the due motion of the blood through the organ, as in plethoric lethargy, or apoplectic coma: here depletion and derivation sometimes answer in restoring the power. There is also a form of palsy due to anæmia, or deficient supply of blood to the nervous centres; this may be removed by an opposite mode of treatment, comprising the administration of stimulants as temporary means of restoring the circulation, and of chalybeate tonics, which act more tardily, by augmenting red blood. In the lethargy of narcotism and asphyxia, volition is often restored by means which excite strong sensations and reflex actions, such as dashing cold water on the face

and chest, the application of ammonia or other stimulating vapours to the nostrils, electric shocks, tickling, stinging with nettles, &c., and although the influence of these is only temporary so long as the stupefying influence remains in the blood, it may nevertheless prove sufficient to prolong life until this influence can be got rid of by other means. The trance or coma of hysteria may often be removed by a turpentine injection, or croton oil purgative, which acts both as a revulsive to the vessels, and a stimulant to the nerves; I have also found the same measures answer in the stupor of anæmia resulting from deficient action in the kidneys; doubtless they effect the elimination of the excremental poison through the intestinal glands. Urea has been found in the intestinal discharges in cases of suppressed urine.

Perverted volition requires different methods of treatment according to its precise nature; the state in delirium tremens is best corrected by narcotics, especially opium; in chorea, by nervous tonics, especially iron and zinc. In delirium tremens there is much involuntary tremor and agitation, independently of all affection of volitional powers, but these are much increased whenever any attempt is made to perform voluntary actions. Neuro-sedatives are best suited to the alleviation of this nervous excitement, as has been already explained (§ 56). Such remedies, however, may fail until the blood is relieved of the irritating matter, the presence of which keeps up the morbid excitement. The same remark is applicable to many cases of chorea, which are not remediable by tonics, until after the administration of purgatives and other evacuants. The connexion of chorea with rheumatism has been frequently noticed, and I have found that such medicines as are useful in rheumatism (for instance iodide of potassium, colchicum, and aconite) promote the cure of chorea in a very marked degree. Its completion is, however, even then to be looked for from the salutary operation of tonic remedies which have a remarkable effect in *steadying* the nervous functions. Hence iron, quinine, and their combinations, are the remedies from which the most lasting benefit is to be anticipated.* These tonics operate in various ways;

* Mercurial tremor affords another good illustration of the principles of treatment here laid down. Iron is its best antagonist, but the administration of this remedy is rarely effectual until the mercury has been, to a certain extent, eliminated from the system through the excretions, and in promoting this object the influence of iodide of potassium is invaluable. I believe the beneficial influence of many of the celebrated mineral waters to be connected with their combination of the eliminant with the tonic power.

they enrich the blood, and equalize and sustain the circulation, thus conducing to support the nutrition and stability of the nervous structures.

147. The treatment of *locally diseased* voluntary power should generally commence with attempts to remove the cause, which, however, is found to vary too much both in seat and nature, to admit of any precise enunciation of remedial measures. The treatment of defective voluntary power comprehends the complex subject of the management of paralysis, which commonly comprises means calculated to restore the circulation through the affected part of the nervous system to its proper state, and sometimes, also, the use of agents which stimulate the part, such as electricity,* rubefacient frictions, and blisters. Strychnia and cantharides, given internally, are supposed to have a directly stimulant action on the motory columns and nerves.†

SECTION V.

DISEASES OF REFLECTED AND SYMPATHETIC NERVOUS INFLUENCE.

148. THE nervous power, by which various movements and processes connected with organic life are excited, may be disordered, and its alterations thus become remarkable constituents in many diseases. The contractions of all the sphincters,—those of the œsophagus, the glottis, the iris, and the eyelid, and the regular action

* In the use of electricity as a means of restoring the lost power of a palsied nerve, it may be well to bear in mind the observation of Professor Matteucci (Lectures on Physical Phenomena, &c., p. 262) that a *direct* current of electricity, from root to branches, exhausts nervous power: whereas an *inverse* current, from branches towards the nervous centre, causes an accumulation and increase of power where it has been previously exhausted. Now as the object in electrifying a paralyzed limb, is not only to develop nervous force where it is weak, but also to exercise it in producing the contraction (and thereby the nutrition) of the muscles, it would seem desirable to alternate the direction of the electric current, from *inverse* to *direct*, giving however a much greater amount of the former than of the latter.

† Phosphorus is a reputed restorer of nervous power, and from its admitted existence as a constituent of nerve matter, I have been induced to test its properties. I first administered it in doses of $\frac{1}{10}$th of a grain dissolved in a little oil. In a few days the fæces became luminous in the dark, and in a few more days I was compelled to suspend the administration in consequence of the supervention of jaundice. This happened in two cases (one, hemiplegia, and the other great nervous debility) and seems to me to demon-

of the muscles of respiration, seem to be sustained, independently of the will, by a nervous influence conveyed first by afferent nerves from the several parts or surfaces to the spinal marrow, and reflected from it through the efferent nerves to the muscles connected with the parts. The full establishment of this important physiological principle we owe to Dr. Marshall Hall.

149. *Increase of this involuntary excitomotory* power is instanced in the spasm of the throat, and sometimes of the sphincters, which occurs in hydrophobia, tetanus, and some hysterical affections. The hurried respiration, convulsive cough, violent retching, and hiccup, which are occasionally presented in these and other nervous diseases, may also be in part traced to an undue influence of the excitomotory nerves of organic life. These actions are sometimes excited by sensations (§ 134), as the breathing by feeling of want of breath, cough by tickling in the air-passages, retching by nausea, &c.; but it is mainly where either there are no such sensations, or where these bear no due proportion to the violence of the excited actions, that we are warranted in the conclusion that the excitomotory function is itself exalted.

A similar exaltation of the excitomotory function, independent of the influence of sensation and volition, is exemplified when the voluntary muscles are deprived of sensation and voluntary motion by disease in the brain itself, or by cutting off the communication between the brain and spinal cord, without extensively injuring the structure of the latter (§ 118). Thus, in paraplegia from injury of the upper part of the spine, the excitomotory power of the nerves of the lower extremities is exalted, and tickling, or mere touching the soles of the feet or legs, will produce convulsive motions, although all voluntary power and sensation be wholly lost.* This phenomenon is sometimes so readily produced as to be a cause of much disturbance to the patient, the mere touch of

strate that phosphorus exerts some specific action on the liver, or its ducts. There was no improvement of nervous power. I have, however, given phosphate of iron, dissolved in an excess of phosphoric acid, with better effect. This is an agreeable, as well as efficient, form of the medicine, but it must be recently prepared, as the insoluble phosphate is soon precipitated.

* The same phenomenon is exhibited in a high degree in the decapitated frog, in which touching the surface excites convulsive movements. A still more interesting illustration sometimes occurs in animals or persons whose cerebral power (sensation and voluntary motion) is impaired by opium or other narcotics; spasms or convulsive actions of the muscles being induced by tickling or pinching the skin, which shows the excited state of the reflex or spinal function.

the bedclothes exciting troublesome startings. The same thing occurs in hemiplegia, but less distinctly, as the cerebral influence is rarely here so completely intercepted. I have known, however, the convulsive motions of a paralysed limb to become so violent in a hemiplegic patient, that it was necessary every night to fasten it down to the bedstead to enable the patient to get sleep.

An instance of involuntary excitement of the muscles occurs in the symptom commonly called "fidgets," which often arises from reflected irritation set up primarily in the lower part of the intestinal canal, or in the uterus: another is seen in the sudden retraction of the testicle by the contraction of the cremaster, in diseases of the kidneys, and other urinary organs, on touching the inner part of the thighs.

150. Under this head we must also glance at convulsions, which, according to Dr. M. Hall's views, and consistently with the phenomena of disease, may be referred to an irritation of the true spinal system. This irritation may be *centric*, as seen in epileptic and apoplectic convulsions from discase in the head, and in those caused by loss of blood; in these cases, the spinal and prolonged medulla being in some peculiar state of irritation, the excitomotory influence radiates therefrom to the limbs and muscles generally. Or it may be *eccentric*, commencing with irritation of the extremities of some afferent nerve, which is then transferred to the spinal centre, and then again reflected thence generally or partially. Convulsions arising from teething, or uterine, intestinal, and renal irritation, are of this nature, and a slighter degree of the same state of things is exemplified in the rigor caused by the sudden impression of cold on the surface, or by passing a bougie into the urethra of a nervous person. The centric and eccentric causes of convulsions, however, often co-operate. The centric excito-motory power being exalted by various influences, its overflow or discharge does not take place until provoked by some occasional irritation transmitted from some nervous extremity. In this view the exalted excito-motory power is the predisposing, and the distant irritation the exciting cause, of the convulsion.*

151. *Partial spasms* caused by *reflected irritation*, are exemplified

* Some modern physiologists conceive that the *sensory ganglia* are the primary seat of epilepsy, and that this is proved by the obliteration of consciousness, and the occurrence of clonic spasm, identical with that which is produced by mechanically irritating these organs. Sometimes the irritation is propagated upwards, and cerebral disturbance results; at other times it is propagated downwards to the spinal chord, and then convulsive movements occur.

in cramp in the legs, excited by the presence of acrid matter in the colon, in diarrhœa, and cholera; spasm of the glottis from a bone sticking in the pharynx, &c. More familiar examples of the same class of reflected irritation are found in sneezing from irritation of the nares, winking from irritation of the conjunctiva, coughing from irritation of the glottis, retching from irritation of the fauces, efforts to evacuate the rectum and the bladder from irritation of these parts respectively. But it must not be forgotten that all these latter examples are connected with obvious sensations; they imply increased excito-motory influence only in the cases in which the resulting action is out of proportion to the sensations.

152. But some of the most remarkable instances of reflected irritation are displayed by the altogether involuntary muscles, the heart, and the muscular fibres of the air-tubes and intestinal canal. Thus inordinate action of the heart (palpitation) is commonly caused by the presence of irritating matters in the stomach, intestines, kidneys, or other viscera (§ 51, 54); nay, we shall hereafter find, that the heart is liable to be excited by considerable irritation applied to any part of the body, as in fever and constitutional disorder. The spasm of the intestines, in colic, is induced by reflex irritation resulting from acrid matter in them; for if it were from direct irritation alone, the spasm would only affect the part touched by the offending matter.* The spasm of the bronchi, so suddenly occurring in spasmodic asthma, also sometimes arises from intestinal irritation. It has long been supposed, and is still a common opinion, that these morbid sympathetic movements are due to the direct nervous connexion which the great sympathetic nerve establishes between the several organs; but this supposition assumes, what experiment has not proved, that the ganglia of this nerve are either centres of reflection,† or that they are sources of nervous influence, which is still more inconsistent with the latest researches. So far as we yet know, the spinal marrow is the centre of reflection in these, as in all the other, examples of reflex action that we have been considering, although the sympathetic nerves are the medium of harmonization.‡

153. When phenomena of inordinate reflex action are general

* Müller's Physiology (by Baly), p. 737.

† It is now generally conceived that the special office of the sympathetic nerves is the production of an influence that harmonizes the chemico-vital processes of the system (nutrition, secretion, &c.) with themselves and with the operations of mind.—Carpenter's Human Physiology, 4th Edition, p. 864.

‡ Carpenter's Human Physiology, 4th Edition, p. 700.

or extensive, as in convulsions, tetanus, and paraplegia, they must be referred to an undue excitement or erethism of the spinal and prolonged medulla; but more partial phenomena may arise from similar excitement of a small portion of this organ alone, or of the incident (afferent) nerve of the part which occasions the phenomena, or of the excito-motory (efferent) nerve of the part which exhibits them.

If we seek to know the causes of this excitement, we shall find that it is sometimes referable to an increased flow of blood through the spinal marrow or its nerves, or through the branches of the sympathetic nerve. Thus the early stage of inflammation of the spinal cord, or of its sheath, is attended with convulsions or tetanic spasm. It is very probable, that the spinal excitement (convulsions) occurring in epilepsy and apoplexy, is in part due to the flow of blood through the medulla being increased in proportion as that through the brain is impeded: considerations based on ascertained causes of convulsive paroxysms, and on the mode in which the encephalic arteries are distributed, countenance this supposition.*

* The explanation of epileptiform attacks, here proposed, deserves, at least, some consideration. It was first suggested to me by observing the symptoms of an epileptic patient who had a sort of tumour on the vertex (which proved to be of hydatid nature) projecting through an opening in the skull. As this tumour lay in contact with the brain, pressure could be communicated through it to this subjacent organ. A slight amount of pressure caused lethargy, or somnolency, in the patient; a greater degree produced stupor and convulsions. Similar results have been obtained from experiments on animals. Slight pressure impairs, without arresting, the circulation through the cerebrum. The stronger pressure stops it altogether, and directs the current of blood which ought to pass there, upon the arteries of the cerebellum and spinal marrow; the functions of their ganglionic masses accordingly become proportionally excited. This then precisely corresponds with the phenomena of the epileptic fit. The slight attack (*petit mal*) consists simply of a transient stupor passing, like a momentary cloud, over the sensorial powers. The severe fit (*grand mal*) comprehends not merely suspension of sensorial and voluntary power, the function of the cerebral lobes and ganglia, but also excitement of the involuntary excito-motory functions of the cerebellum and medulla. But this diversion of the cerebral circulation may be produced by other means, besides pressure; there are various disturbances of the quantity and motion of the encephalic blood that are capable of effecting it: thus convulsions with insensibility—*i.e.* medullary excitement with cerebral syncope—occur in consequence of extreme loss of blood, as well as in consequence of fulness;—in consequence of depraved quality, as well as of disordered quantity. It would far exceed the limits of a note to enter upon a detailed statement of cases illustrative of these views, but there is one natural provision concerned in the results that may be pointed out, namely, the greater proximity of the medulla and cerebellum to the source of arterial supply (especially through the vertebral arteries, which are least liable to derangement) so that under most circumstances of irregular flow of blood these organs get the first and best share, often at the expense of the cerebral hemispheres. This doubtless is a salutary arrangement to secure the maintenance of those functions that are most immediately important to life.

It appears, from an experiment of Sir Astley Cooper's, as well as from the occasional occurrence of convulsions during syncope, that an arrest of the arterial current sufficient to cause suspension of the cerebral functions, causes a momentary excitement of the medulla. In other cases, the excitement seems to be of even a more direct nature. Strychnia in a poisonous dose excites the medulla so speedily, (causing tetanic spasm,) that its effect can scarcely be due to increased flow of blood. This agent, indeed, seems to be electively attracted by the affinities of the spinal ganglia, as opium and alcohol are by the encephalic centres. So, too, we know, that mechanical irritation of the spinal marrow or of its nerves will cause convulsive motions; this is exemplified in the effect of tumours and spicula of bone in the spinal canal, in the head, or in the course of nerves. But nothing exhibits this element of nervous irritation (apart, so far as is yet known, from vascular influence) so fearfully as traumatic tetanus. The irri-

Life may go on for some hours without the aid of the brain, but not even for a few minutes without the influence of the medulla, as this sustains the respiration. Sleep is a natural and prolonged condition like the *petit mal* of epilepsy; the cerebral power is impaired, whilst the energy of the medulla is enforced and augmented during its continuance. The close affinity between sleep and epilepsy is further shown by the way in which somnolency commonly follows the occurrence of epileptic attacks, and these frequently supervene during sleep.

The following remarks comprise certain practical bearings of this subject, which my own experience has suggested:

In a majority of instances convulsive fits of the epileptic or epileptoid character, have been immediately preceded by symptoms of disturbed circulation, such as palpitation, or strong action of the heart, throbbing in the carotids, sudden change of colour and coldness of the extremities; these signs being sometimes obvious to others, when unobserved by the patient.

The fits may sometimes be prevented or arrested by the adoption of measures which tend to subdue disturbances in the circulation; as by making firm pressure on the carotids (Dr. Parry), dashing cold water on the face and neck, and plunging the hands and feet into hot water.

The frequency of the fits is often reduced by remedies which equalize the circulation, either by reducing it where there is excitement or occasional palpitation, (hydrocyanic acid, digitalis, and aconite act in this way) or by raising its power when in a depressed state and irregular (iron, quinine, zinc, silver, and other tonics do this) or by purifying the blood when it is depraved (iodine and other eliminants possess this power).

The undue susceptibility of the nervous system itself in many such cases is of high importance; many of the remedial means alluded to above act mainly upon it, as also do others which tend to improve the nutrition of the nervous structures.

The more rational treatment of convulsive paroxysms (whether of the decidedly epileptic or mere hysterical class), based upon these views, proves at least more successful than the too prevalent empirical plan of using first one remedy, and then another, reputed to be specific, and in doses increased to a hazardous extent.

tation here begins in a distant nervous branch, and is propagated *to the* medullary centre, the excito-motory function of which at length exhibits a state of erethism, which destroys life either directly by tonic spasm (§ 114) of the muscles of respiration, or by exhaustion. Tetanus may be defined to be dependent on an undue excitability of the entire series of the spinal ganglia. Slight impressions then produce violent reflex actions; when these are once established they are kept up by the irritation present in the spinal ganglia. Then the removal of any cause of nervous irritation fails to be of any service. In hydrophobia the irritation seems to be transmitted from the sensory ganglia or from the cerebrum—while in tetanus it issues directly from the spinal cord.

Another cause, which may be fairly assigned as sometimes increasing the involuntary excito-motory function, is accumulation by rest. The augmentation in narcotism from opium is of this nature, and also in injuries of the spine (§ 149), which suspend the exhausting influence of volition on the whole or part of the marrow, so that the nervous energy accumulates therein, and becomes unusually abundant. There is a natural increase of excito-motor power in sleep, which by suspending the sensorial functions, augments the energy of those of the medulla; but this accession of power, which then maintains the movements of respiration, also disposes to the occurrence of spasmodic attacks; hence the fits of epilepsy and asthma commonly come on during sleep. So likewise sedentary habits, and too much indulgence in sleep, may cause an accumulation and morbid excess of involuntary nervous power, and develop convulsive and spasmodic symptoms, which are the result of its overflow. True coma differs from sleep mainly by the functions of the sensory ganglia being suspended or destroyed. In the slightest forms, as in hysterical coma, the cerebral functions are not abolished, but only much impaired.

154. *Deficiency* of the reflex, or involuntary excito-motory function, is exemplified in forms of paralysis which affect the sphincters, the eyelids, the muscles of respiration, and other parts whose normal action is sustained by these means (§ 148). When this function is generally and considerably impaired, the result is fatal, because respiration, deglutition, and other actions essential to life, are arrested. It is by interfering with these actions that apoplectic coma and narcotism destroy life; and the state of sinking in excessive weakness or great depression, when the urine

and fæces are voided involuntarily, and the breathing is irregular and gasping, being forced by voluntary effort, further illustrates failure of the reflex power. From the same cause coughing and expectoration become inefficient in clearing the air passages of mucus; hence the bronchial and tracheal rattles which precede death. As these movements are the last to fail, so, in recovery from asphyxia, syncope, and other similar states of partially suspended animation, the actions connected with the reflex function are the first to return with the restoration of life; vomiting, coughing, and sneezing are among the early signs of reaction, under such circumstances. The steady tonicity of the muscles by which they are kept in their places when at rest is much under the influence of the spinal function; hence when it fails an unsteady tremor affects the various muscles, which increases as strength declines. So also in the decline of life from age or extreme debility, the sphincters act imperfectly; incontinence of urine and fæces, drivelling, lacrymation, and a sighing, moaning, or gasping breathing, betoken the failure of the nervous powers most intimately connected with the processes of life.

A failure of the medullary function, similar in kind, but less in degree, is exhibited in all states of extreme debility, whether from excessive fatigue or excitement (§ 64, 65), or from directly depressing or sedative influences, as in adynamic fevers (§ 105). A person in this state is *too weak to sleep;* for the medulla, partaking of the general exhaustion, cannot maintain the respiration without assistance from voluntary efforts. Hence a feeling of oppression and frequent sighing banish all repose; or if sleep do occur, it is disturbed by the startings and fearful dreams occasioned by the painful sensations of imperfect breathing and the distressing efforts which they excite.

155. *Remedial measures.*—As with other instances of exalted nervous function, so with *excessive reflex action,* when it depends on inflammation, or determination or congestion of blood in the medulla, the most suitable remedies are such as are directed towards these states; the same measures in less active degrees are also often useful in hysterical affections, when these are accompanied by fulness of habit and spinal tenderness. But in my own experience cases of pure inflammation of the medulla and its membranes, requiring active antiphlogistic treatment, are rare. Instances of a rheumatic kind where vascular excitement of the

medulla is kept up by the irritation of morbid matter in the blood, are far more common. Under such circumstances the most effectual remedies are agents which promote elimination, as for instance colchicum, iodide of potassium, guaiacum, and turpentine. In simple irritation of the nervous centres (as in tetanus, hydrophobia, poisoning with strychnia, &c.), a narcotic or sedative which is able to lower the exalted function, is the influence that would seem to promise the best results. We possess some agents which efficiently reduce the energies of the spinal system, and cause general relaxation of the muscles; such are hydrocyanic acid, woorara, resinous extract of Indian hemp, codeia, belladonna, and conium: these drugs may themselves destroy life by arresting the function of the medulla oblongata, and through it respiration; but this very action renders the remedies almost as dangerous as the disease. One of them, hydrocyanic acid, is also further hazardous on account of the sedative influence which it exerts over the heart. Perhaps the least dangerous, and in this sense therefore the safest medicines where full doses are required, are the extracts of belladonna and Indian hemp; and these remedies have recently been successfully exhibited in cases of tetanus. The inhalation of chloroform is also a powerful means for subduing this, as well as other forms of excited nervous functions, and although it can only be viewed in the light of a palliative in tetanus and hydrophobia, it has been of direct service in some of the less intense kinds of convulsive disorder. In the slighter irritations of the medulla, neuro-sedative medicines, given in moderate doses, often prove beneficial. Thus hydrocyanic acid is a very efficacious remedy in vomiting, nervous palpitation, and hiccup; it is likewise useful in convulsive cough, in which, however, as well as in spasmodic asthma, the extracts of belladonna and stramonium are still more effectual. The same medicines, and opium, are often beneficial in relieving the spasms of colic, dysentery, dysuria, and dysmenorrhœa.

Some medicines, which act as stimulants to the heart and vessels, and to the cerebral functions, seem to operate as sedatives to the medullary system: such are the stimulant anti-spasmodics, ether, ammonia, musk, sumbul, essential oils, gum resins, creosote, chloroform, and alcohol; these are useful remedies in spasmodic and convulsive affections in weak subjects without inflammation; they probably operate by giving vigour and equable diffusion to the circulation, and by preventing undue local determination and

gestion of blood in the nervous centres. External heat and counter-irritation act in a similar way.

There is another class of remedies which have some power in reducing the excitability of the spinal excitomotory system—namely, tonics, especially those prepared from metals: but the operation of these is gradual, and therefore probably indirect. The sesquioxide, iodide, valerianate, and other preparations of iron are efficacious in chorea, and perhaps in the more chronic forms of tetanus. Nitrate and oxide of silver, valerianate, sulphate and oxide of zinc, sulphate and ammoniaret of copper, and trisnitrate of bismuth, have been found to diminish the attacks of epilepsy, hysterical convulsions, spasmodic asthma and cough, gastralgia, dysentery, and other like affections. The chief operation of these medicines is obviously on the vascular system, to which they prove astringent and tonic, but it is uncertain whether their beneficial action in nervous diseases is of this kind only, or whether they exercise any more direct influence on the nervous system besides equalizing the circulation. The same question is open with regard to certain regiminal means which are efficient in reducing nervous excitability, such as cold bathing, country air, change of air, and exercise. The latter, however, no doubt may prove useful by exhausting the superfluous nervous power (§ 153) through another channel, that namely of voluntary motion.

The best remedies for *defective* or *failing* medullary function are stimulants, narcotics, and various strengthening measures. Fatal states of sinking have sometimes been removed by the free administration of ammonia, ether, brandy, and other stimulants; the best proof of the beneficial operation of such agents is afforded when they procure refreshing sleep, which in itself is a source of renewed power. Narcotics also seem to be indicated, but in extreme conditions of weakness their indiscriminate employment is hazardous, as they may paralyse the little remaining power, and lull the patient into the sleep of death (§ 56. Note). When given they should be preceded by, or combined with, stimulants; and those narcotics should be selected which have the least depressing action, such as opium, æther, and henbane. Other means must, however, then be adopted to sustain the power restored by the stimulants, especially the administration of nourishment frequently in a liquid form; complete rest in the horizontal posture, and the exclusion of all exciting and exhausting influences; such as light and noise.

REFLECTED AND SYMPATHETIC SENSATIONS.

156. Clinical observation teaches us that not merely motory impressions, but those also which cause sensations, may be *reflected*, so that when the impression is made on one part, the sensation is experienced in another. I do not allude to the fact that a stroke on the nervous trunk produces feelings referred to its branches, but I advert to impressions on the ultimate distribution of one nerve producing sensations in parts supplied by another nerve, or by another branch of the same nerve. The following are examples of this kind. Touching the external auditory meatus causes a tickling sensation in the glottis. A calculus in the kidney sometimes gives rise to pain and numbness in the testicle and thigh; one in the bladder produces pain referred to the extremity of the penis. Congestion of the ovaries and uterus causes pain in the back, loins, and thighs. Ascarides in the rectum induce itching of the anus, and of the pudenda in females. Congestion of the liver is sometimes accompanied by pain in the right shoulder-blade; and a disordered state of the stomach, occasionally with pain in the left shoulder-blade. In angina and gastrodynia the pain often extends to the whole chest; and in the former especially, it radiates to the left arm. Severe frontal headache is almost instantly caused in some persons by acid ingesta, in others by eating ice. Irritation of the intestines, such as is experienced in cholera and colic, (especially painter's colic), frequently causes pain and tenderness in the legs and feet, even when there has been no cramp or other excito-motory phenomena. Temporary neuralgic affections, generally described as spinal irritation and excessive cutaneous sensibility, seem to be due to similar causes. Instances of excessive sensibility often amounting to considerable pain, are very common, particularly in the female sex, and are occasionally very puzzling to the practitioner from their resemblance to inflammatory affections. They occur chiefly in nervous individuals (§ 126); but not uncommonly in others not constitutionally nervous they form part of a temporary nervous susceptibility connected with weakness and inanition, after losses of blood and other exhausting influences (§ 63-64). An example or two will suffice to show that they belong to the phenomena of reflex nervous action. A young female has an attack of tonsillitis—of pleurisy, of hepatic congestion, of gastric derangement, or of uterine irritation,—and after the symptoms of these affections have subsided, suffers pains of more or less intensity near

the seat of the primary disorder, so as to give the appearance of a relapse. The wary physician remarks, however, that the pain is of a sharper and more shifting character; that there is a complete absence of such febrile and functional disturbance as real relapse would cause, and that there are peculiar nervous symptoms, especially extreme sensibility of skin traceable to a corresponding part of the spinal column behind, where on pressure there is tenderness, and sometimes radiation of pain to the seat of suffering in front of the body. The real truth is that the spinal irritability has been exalted by the primary disease, particularly in that portion which corresponds in position with the affected organ, and that this irritation is propagated to the sensory centres, and then reflected on the cutaneous and other nerves, occasioning in their extremities the abnormal sensations. Thus after tonsillitis the morbid sensibility and tenderness is experienced close to the spines of the cervical vertebræ on the same side. After pleurisy, it is near the spines of the dorsal vertebræ; after hepatic and gastric disorder, at those of the lower dorsal vertebræ; and after uterine and gastric disorder, along the lumbar and sacral portions of the spine, the pain then being very apt to be intense and to be extended over the loins, pelvis, and thighs. These are all so many several examples of what is commonly called *spinal irritation.*

In these and other analogous instances, the morbid sensations cannot be referred to direct nervous impressions, but to an influence propagated from the spinal centre to the sensory ganglia, and then reflected thence.

Involuntary *reflex actions* issue from all the great centres of the nervous system — the spinal, the sensory, and the cerebral ganglia. The reflex actions determined by the sensory ganglia are instinctive, and in man these are masked by the superior cerebral influence and will; but they are seen in full operation in morbid states where there is complete exhaustion and abeyance of cerebral power, as after repeated attacks of mania or epilepsy, and also in instances of congenital idiotcy, where the cerebral influence has never been established. Chorea is something of this nature; its seat is in the summit of the cranio-spinal axis. The fact that the symptoms cease during sleep is inconsistent with the notion that it is the spinal centres that are solely or mainly involved. In chorea there is augmented activity of the sensory-motor centres, and diminution of the power of will.

The sympathies subsisting between some organs are very re-

markable; this is especially the case with the breasts and the uterus. Applying the infant to the breast commonly induces uterine pains in women recently delivered; the catamenial discharge has been induced in some instances by stimulating applications to the breasts.

157. The *remedies* most effectual for the relief of reflected morbid sensations are—1st, such as remove the irritating cause; and 2nd, such as deaden sensibility (§ 137). The peculiar efficacy of trisnitrate of bismuth and hydrocyanic acid in relieving gastrodynia and some kinds of angina, is, however, not explicable through any narcotic quality; but is probably due to an influence exercised over the power of the nerves to transmit sympathetic irritations. These morbid sympathetic susceptibilities are often exalted, in common with other nervous functions (§ 126, 148) by weakness or irregularity of the circulation (§ 153); and are generally diminished under a tonic plan of treatment, especially when the metallic tonics, preparations of iron, nitrate and oxide of silver, sulphate of copper, arsenic, &c., are used.

The peculiar affection, alluded to above as spinal irritation, is no exception to the applicability of this mode of treatment. In a few instances leeches or blisters to the tender part of the spine prove serviceable, but such means are rarely necessary, and prolonged or excessive depletion and counter-irritation are positively injurious and tend to aggravate the evil. Anodyne applications to the spine, as of chloroform, belladonna, aconite, arnica, and morphia, alternated with sponging with tepid or cold vinegar, or spirits and water, a tepid or cold douche, or dry cupping in the vicinity of the part, are more effectual than weakening measures, and the permanent cure is most likely to be completed by a plan for invigorating and equalizing the circulation and nervous functions.

SECTION VI.

DISEASES OF SECRETION.

158. The power of secretion appears to be a vital endowment of the ultimate cells or vesicles of secreting structures.* It is uncertain whether the process consists in the formation of the peculiar matter of the secretion, or merely in its separation from the blood. In the case of the urine and bile, these principles seem really to be formed in the blood without the aid of the secreting organs; for urea has been found in the blood of animals whose kidneys have been prevented from acting by ligature of their blood-vessels, or by extirpation; and both urea and some of the principles of the bile (colouring matter and cholesterine) are found in the blood and in various parts of the body when the kidneys and the liver respectively have been disabled by disease. But whether the secreting structures assist in the formation of the secretions, or only effect their separation, their elective power is equally a peculiar attribute of life, and inexplicable at present by any physical or chemical law. Thirty years ago† I advocated the opinion more recently advanced by Dumas and Liebig, that the formation of the principles of the chief secretions takes place through chemical affinities, (especially those of the absorbed oxygen and the constituents of the blood), controlled by vital agencies; still in this view the power by which the liver separates bile; the kidneys, urine; mucous membranes, mucus, &c., is to be regarded as a vital property.

We are then led to consider secretion as a peculiar property of the secernent structures, just as much as we do irritability, of muscular fibre (§ 110); and as such, disorder of secreting power constitutes a primary element of disease. In doing this we avoid the hypothesis of some physiologists, who ascribe secretion to nervous influence, which is a notion by no means in accordance with numerous ascertained facts.

159. In reviewing the other disorders of vital structures, we

* Muller De Glandularum penitiori structurâ. Henle, Allgemeine Anatomie. Goodsir, Trans. Royal Society of Edinburgh, 1842. Bowman, Phil. Trans. 1842.

† In a thesis, *De sanguine ejusque mutationibus*, Edin. 1824. See also Med. Gaz. September and October, 1835.

have found that many are plainly referable to changes in the supply of blood to the respective textures (§ 113, 127, 131, 133, &c.). The same influence operates still more decidedly in producing variations in the process of secretion. The blood being the material from which secreted matter is supplied, modifications in its quantity or quality surely affect the quantity or quality of this product. Thus when an increased flow of blood takes place to a mucous membrane, its secretion is increased, and sometimes rendered more acrid than usual; but a congested state of the same membrane rather impairs the secretion. The most common causes of altered secretion are such as operate on and through the sanguiferous system.

160. But affections of the nervous system, and of the mind, which acts through that system, also influence the secreting process; this is shown by the mouth watering at the sight, or thought, of a good meal; by the bilious diarrhœa that mental agitation causes in some persons; the large flow of limpid urine after nervous agitation; the tears excited by grief or other strong emotion; and the unwholesome quality of a nurse's milk when she is in a state of anxiety or apprehension. We do not however know whether these influences act by altering the flow of blood (§ 159), or, in a more direct way, by modifying the vital properties of the secreting organ (§ 158).

161. The importance of this element of disease may be estimated by the universality of the process of secretion, which includes both the formation of *excrementitious* products (only to be voided out of the system) and *recrementitious* products, (concerned in effecting digestion, assimilation, and nutrition,) and also by the extent of its effects, in relation both to the destination of the secretion, and to the condition of the blood from which it is separated. The several processes of secretion may be influential in producing diseases through being either EXCESSIVE, DEFICIENT, or of a PERVERTED kind.

162. EXCESSIVE SECRETION of any kind, whether of bile, urine, mucus, or anything else, may weaken by the drain which it causes from the mass of blood (§ 28, 71); and the debilitating effect is in proportion to the quantity of the loss, and to the amount of the animal matter which is contained in the secretion. Thus an excessive secretion of bile weakens more than that of thin mucus. But each secretion has also peculiar effects which are connected

with its office and composition; and these effects may tell *forwards*, on the parts to which the secretion goes, and *backwards*, on the secreting organ and on the blood from which the secretion is formed.

163. The *forward* effects of an excessive secretion of bile depend on its stimulating properties. It irritates the intestinal tube, causing bilious diarrhœa or cholera. The symptoms of this disorder consists in an exaggeration of such properties of the alimentary canal as have already been spoken of as elements of disease. Thus the irritating bile causes increased irritability (§ 113), and more rapid motion of the contained matter through the intestinal tube; pain from exalted sensibility (§ 134, 135); vomiting, straining, and cramps, from exalted excitomotory function (§ 149, 151); and profuse mucous secretion from excited secernent function (§ 162). An excessive secretion of mucus into the intestines may cause only simple diarrhœa; but if it be into the bronchi it may occasion dyspnœa and cough, and, if not expectorated, even suffocation. Excessive secretion may in the stomach cause pyrosis or waterbrash, the liquid being sometimes acrid, and also nausea and vomiting, as well as eructation. The excessive discharges from secreting organs generally constitute fluxes or profluvia; and those from internal enclosed serous surfaces, or cellular texture, constitute dropsies. The effects produced vary according to the situation.

164. But excessive secretion also acts *backwards*, on the secreting *organs*, and on the *blood* from which it proceeds. It often weakens the vital powers of the *organ*, so that it subsequently becomes torpid so far as its proper function is concerned. Thus after diarrhœa the bowels often become confined, with defective secretion. So, too, in cases where an excessive secretion continues for a long time, it generally becomes impaired in its quality, because the secerning organ is weakened and rendered unable to perform its proper office.

165. Excessive secretions, if rich in animal matter, not only reduce the mass of the blood, but often also affect its composition. Thus bile and urine, which differ much in composition from the blood, if separated in unusual amounts, must leave that fluid changed. Urine contains a large proportion of azote; its excessive separation from the blood therefore leaves a comparative predominance of hydrogen and carbon in this fluid. The bile, again,

eliminating processes are supplied be the principles of the blood itself, or the decayed constituents of tissues, or matters derived from the food, the co-operation of all is equally required to maintain uniformity in the composition of the circulating fluid; if one of these processes is more active than the others, the blood must suffer from the excess of such matters as the less active processes allow to accumulate in it (§ 68, 69). A practical illustration of this position is offered in the case of bilious diarrhœa or cholera. These fluxes of bile are either accompanied by a highly loaded state of the urine, or by fever; in the latter case, the fever does not subside until the urine becomes very copious, or deposits an abundant sediment. The most probable interpretation of this fact is, that the excessive secretion of bile disorders the composition of the blood; so long as the kidneys rectify this disorder by separating in greater abundance the solid contents of the urine, no fever results; but if the kidneys fail in their task, fever ensues, and continues until they resume it; then a free secretion from them and copious urinary deposit becomes symptomatic of the decline of the fever.*

* Note by Dr. Mann.—In order to estimate the influence which disordered secretion may have in the constitution and aggravation of disease, it may be useful to glance at some of the more recent conclusions of physiologists respecting the chief secretions.

The entire action of the liver in the animal economy has not been yet satisfactorily determined, but all physiologists now seem to be pretty well agreed that at any rate it removes from the blood those hydro-carbonaceous products of the destruction of tissues, that cannot be converted into simple sugar and fat, and that it does this by changing them into glyco-cholic and tauro-cholic acids, which perform a certain definite office in the digestive process, and are then carried off from the lungs as carbonic acid and water, their sulphur and alkaline bases being thrown into the urine. But it is also now clear, that both the liver and kidneys eliminate superfluous alimentary matters, as well as the products of disintegration of the organs. The liver turns all forms of saccharine matter con-

166. The *remedial measures* that are serviceable in cases of excessive secretion well illustrate the view that has just been given of the balancing office which the secretions are designed to fulfil. In so far as excessive secretion is dependent on the quantity and quality of the blood (§ 159), the treatment should be addressed to this fluid: it may be attacked by depletion, derivation, and evacuation, in cases of congestion or determination of blood; and in such cases the excessive secretion itself should not be hastily checked, as it may be a natural means of relief; nay, in some cases, it may even be most speedily arrested by means which for the time increase it: thus a large dose of calomel will sometimes, after first purging, stop a bilious diarrhœa connected with an engorged liver, which astringents fail to check. But where the excessive secretion proceeds more from nervous and other sources of irritation (§ 160), and causes weakness and disturbance of the

tributed by the food into *liver-sugar*, and all kinds of fat from the same into *liver-fat;* and also makes the same substances out of protein compounds. Liver-sugar and liver-fat seem to be in a peculiarly favourable state for undergoing the process of further oxidation and decomposition. M. Bernard's experiments seem to point out that the liver also exercises a subsidiary assimilative action, beyond its excernent one, by rendering albumen more fit to be carried through the channels of the circulation, and even by forming fibrin out of its material. The *principal* purpose performed by the urine is unquestionably the removal from the blood of worn-out azotized matters that have done their work. The urine of children contains a larger proportional amount of urea compounds than that of adults, because the processes of disintegration are going on very actively in their bodies. The quantity of urea and sulphates in the urine is augmented by muscular exertion. But on the other hand the amount of alkaline phosphates is increased by mental exercise, the phosphorus proceeding from the disintegration of nervous substance. In inflammatory disorders of the brain, where the disintegration of its texture is accelerated, the phosphates of the urine always become abundant. The kidneys, however, not only carry off the effete azotized matters, phosphates, and superfluous water, but they also receive many other foreign matters that may be introduced from without in hurtful quantities, and it is remarkable that these are removed more readily whenever the kidneys are stimulated to increased action. Wöhler has shown that those soluble salts are most readily got rid of out of the system that most easily determine the blood towards the kidney. The effete organic matters, on the other hand, cannot be removed by the same means as readily, for Professor Krahmer has shown that when *they* are in excess in the blood, diuretics rather produce irritation and congestion of the kidneys, with suspended action,* than increased action. The alkalies, their carbonates and vegetable acid salts, however, seem to augment the quantity of organic matter in the urine, as well as of inorganic salts.†

Recent researches have further proved that common salt increases the amount of urea (Bischoff), and liquor potassæ has the same effect, and further remarkably augments the excretion of sulphuric acid in the urine (Parkes).

* Hellor's Archiv. Dec., 1847.

† Golding Bird in Med. Gazette, 1848. Vol. xlii., p. 230.

functions, it is more important to check it at once. Secretions are diminished by influences which act as general tonics or astringents (§ 124), and by others which operate only on particular organs. Of the former class of agents are, cold applied to the part, common astringents, such as alum, superacetate of lead, sulphates of zinc and copper, gallic and tannic acids, and substances which contain them, as nutgalls, oak bark, rhatany root, catechu, matico, and mineral acids, &c. These act most surely when directly applied, as instanced by their use in diarrhœa and leucorrhœa; but they seem to have some effect also through the medium of the circulation, for when taken internally they reduce the secretions of the air-passages and skin. Of the agents which more specifically diminish the secretion of particular organs, without exercising any *general* astringent effect, may be mentioned opium, which remarkably lessens the secretions of the liver and intestines, and sometimes that of the kidneys too.

If an excessive secretion have already caused febrile disturbance, great advantage will be found to result from the use of measures which increase other secretions, and in this way the balance of the normal condition of the blood is restored, as before explained (§ 165). It is thus that saline diuretics and diaphoretics are highly serviceable in bilious cholera. In renal irritation with copious secretion of lithic acid, blue pill, which augments the secretion of bile, is often beneficial. These means may be supposed to operate partly as derivants; but the manner in which they remove the febrile irritation, after the reduction of the excessive secretion, renders it most probable that they act also by removing from the blood dregs left by the inordinate separation of the matter of the single secretion which has been in excess (§ 165). No practical physician can doubt that we possess medicines which often augment the secretions of particular organs (mercury that of the liver and salivary glands, colchicum that of the kidneys, &c.), but there is a limit to the operation of these agents; the limit may however be extended by simultaneously acting on other organs which maintain the balance. Hence in any disturbance of the secretions, especially if it continue long, combinations of medicines are much more useful than the administration of such as fulfil one indication only; thus experience has sanctioned the practice of conjoining mercurials with diuretics, and antimonials with salines, &c.

167. Secretions may become *deficient* in consequence of a

weakened state of the whole circulation, or of that of the secreting organ, as in the case of exhaustion from previous excitement (§ 164). They may be diminished by depressing influences which paralyse generally the vital powers, as seen in the operation of the zymotic and narcotic poisons (§ 56, 64, 65). Or they may be checked by agents like cold and astringents, which increase the tonic contraction of the vessels of the part (§ 77), or by those which influence the whole sanguiferous system, as is the case in the hot stage of fevers (§ 85, 421).

Deficient secretion of any natural or habitual discharge (§ 70) may cause a fulness of the blood-vessels; general, if the secretion be naturally copious; local, if it be trifling in quantity. Thus deficient secretion of urine or bile may lead to general plethora, or to extensive local congestions, which may end in dropsical effusions, fluxes, hæmorrhages, or inflammations. Diminished secretion of tears or saliva merely causes fulness and dryness of the parts immediately concerned.

The morbid effects of deficiency of secretion may be excited both *forwards*, that is on the parts for which the secretion is destined, and *backwards*, that is on the organ by which, and on the blood from which, it should be eliminated (§ 162).

168. Deficient secretion of bile causes disorder in the latter stages of digestion. The neutralization of the acid in the chyme, and the separation of the chyle, to which the bile seems to contribute, are imperfectly performed, and sometimes colic and diarrhœa, sometimes costiveness, result. Deficient secretion of mucus in the intestinal canal and bladder exposes their lining membranes to suffer more irritation from the matters that are habitually in contact with them. Deficient secretion of mucus on the respiratory membrane may lessen the facility with which the air and the blood act on each other. Insufficient secretion of cerumen in the ear, or of saliva in the mouth, impairs respectively the faculty of hearing, and the process of mastication. A want of synovia in the joints has been supposed to be the cause of imperfect motion and subsequent inflammation of their structures.

169. The effect of deficient secretion in causing congestion of the organ concerned, has been already noticed: the concomitance of congestion and defective secretion, in the case of the liver, the kidneys, and mucuous membranes, is well known; but either may stand in the position of cause or effect, for circumstances which

increase the secretion diminish the congestion, and influences which reduce the congestion tend to restore the secretion.

170. The most remarkable of the *backward* effects of deficient secretion are instanced in cases of the excretions (§ 70). The materials of urine and bile appear to be positively noxious, and to poison the system if not separated from the blood. Hence the sudden suppression of urine or bile causes typhoid symptoms, extreme depression, and coma, which may speedily end in death; and in such cases, urea, or the colouring matter of the bile, has been found in the blood and in various organs. Where the suppression is incomplete, the poisoning process more tardy, various functional and visceral derangements are produced, such as delirium or lethargy, convulsions, dyspnœa, palpitation, vomiting, diarrhœa, dropsical effusions, and structural degenerations. But the amount of these effects will depend on the extent, and especially on the suddenness, of the diminution of the excretion; and it is very remarkable, when it is very gradual, how little disturbance it may for some time induce. In these gradual cases, excrementitious matters may be detected in the blood, and in other fluids and solids of the body, more certainly and decidedly than when the suppression is sudden. Thus in some structural diseases of the liver, the colour of the bile becomes manifest first in a yellow, and then from accumulation, in a deep greenish colour in all the textures, constituting the yellow and the black jaundice. In cases of extensive granular degeneration of the kidneys, in which scarcely any urea is excreted by these glands, this principle is found in the blood and various fluids of the body. In the case of a patient of mine affected with ascites from disease of the heart, liver, and kidneys, Dr. Garrod obtained nearly four grains of nitrate of urea from an ounce of the peritoneal fluid, and a considerable quantity of bright yellow solid matter, probably bilious. In other cases I have known the fluid of ascites and anasarca, induced by diseased kidneys, to emit a decidedly urinous smell, and to exhibit on analysis easily appreciable quantities of urea. One of my pupils, Mr. Edward Palmer, detected urea in the serum contained in the ventricles of the brain, in a case of fatal apoplexy connected with granular kidneys and diseased heart.

The inequality observed in different cases with regard to the production of symptoms from uræmia (urea in the blood) has led many to question the power of urea to cause the symptoms

ascribed to it (coma, convulsions, &c.); and it is said that urea has been artificially introduced into the blood of living animals without any morbid effects ensuing. Professor Frerichs, of Kiel, suggests the hypothesis that the poisonous properties of urea in the blood depend on its conversion into carbonate of ammonia through the agency of some ferment. If the urea be abundant, and the conversion into carbonate of ammonia be sudden, coma or apoplexy is the result: if more slow, the symptoms are those of stupor, prostration, and convulsions. In support of this notion, Dr. Frerichs states that he has detected carbonate of ammonia in the breath during uræmic intoxication; and he has succeeded in causing similar symptoms by injecting a solution of carbonate of ammonia into the blood-vessels.

The clinical history of disease abundantly illustrates the resources which nature brings into play to relieve herself from the mischief dependent upon failure of any of the great eliminating organs. Other portions of the excretory apparatus then throw off the offending matters. Thus when the action of the liver is obstructed the urine manifests at first an increase of its ordinary pigmentary principle, and afterwards the presence of a new matter of the nature of purpurine or purpurate of ammonia, a highly carbonized body. If the elimination of the bile be further impeded, the true bile pigment presents itself in the urine, this secretion then becoming of a dark orange, or olive green colour. Such vicarious action of the kidneys must be viewed in the light of relief designed for the service of the general system. I have known cases of jaundice in which the redundancy of bile material was thus disposed of during several months, without such rapid failure of health being induced as might have been anticipated under the circumstances. In cases of Bright's disease where there have been urgent symptoms of poisoned blood at first, these are alleviated under the operation of purgative medicines; a portion of the urea, and other urinary constituents being removed through the intestinal surface; these principles indeed may be detected in the secretions of the intestines. These facts serve, not only to explain why the diminution of an excretion is less injurious when it takes place so gradually that there is time for a compensatory operation to be established, but also to point out an important therapeutical means whereby such a result may be hastened or brought about.

The glandular apparatus of the intestines are important excretory organs whose main specific function seems to be the removal of putrid and otherwise offensive matters from the system. Hence when from extreme weakness and failure of the vital powers, from imperfect nutrition, or from the presence of a septic and poisonous ferment in the body, the normal process of decay and decomposition is quickened, the alvine excretions become excessively fœtid, and the worst results may follow if they are locked in or suppressed under such circumstances. In low and typhoid fevers, great relief often ensues upon the occurrence of fœtid diarrhœa. Suppression of the catamenia also induces disorder not only through the production of a state of plethora, but also by rendering the blood depraved; this follows as a natural consequence from the fact that the catamenial discharge contains matter of an excrementitious nature.

171. The excretions are deficient in most idiopathic and symptomatic fevers; and there can be little doubt that many of the constitutional effects of such fevers are in great measure due to this important fact. The positively noxious properties which excrementitious matter retained in the blood is known to possess (§ 170), must be taken into account when we attempt to explain the states of constitutional irritation and depression, and perversion of functions, which fevers so generally present. The morbid conditions of the blood, manifested in some such cases in its fluidity and in petechial appearances of the skin, may also be in part referred to defective elimination of effete matter;* and it is when the secreting organs recover their power, and a diarrhœa occurs, or a copious discharge of highly loaded urine, that these appearances cease. It is very probable that severe mechanical injuries or shocks (§ 52), and animal and other poisons (§ 85, 105, 57, &c.) sometimes operate by thus injuring the vital powers through which the blood is continually purified from its own noxious products; and that this is one of their modes of action seems almost certain from their effect in suppressing or impairing the natural excretions. Accordingly, in such cases, urea has sometimes been detected in the blood.

There can be little doubt that a morbid element, which in its

* Purpura I have found to be often connected with hepatic congestion and imperfect excretion of bile; it is most effectually removed by remedies which promote the restoration of the proper secretion.

extremes acts so injuriously as to cause serious disorder, and even speedy death, must in slighter degrees be still an important cause and constituent of disease; and I believe that gout, rheumatism, and many cachectic states leading to diseases of nutrition, degenerations, dropsies, &c., are essentially connected with defective excretion. It is a common observation of gouty patients that their urine is either more scanty or paler than usual before a paroxysm, and they hail the appearance of a red deposit in the secretion as an indication of the departure of the enemy. Dr. Garrod remarks that before the gouty fit, and at its commencement, there is a disappearance of lithic acid from the urine, and an increase of it in the blood; and that the converse takes place as the attack declines.

172. *Remedial measures.*—Deficient secretion may be caused by deficient or excessive supply of blood to the part, as in various cases of anæmia, congestion, and inflammation (§ 159). It must therefore be treated by the remedies adapted to the precise condition present: thus stimulants restore secretions that are scanty in consequence of a defective supply of blood; but depletion and derivation may be the best remedial measures, when they are stopped by inflammation and congestion.

173. But sometimes the first disorder is in the secreting structure itself (§ 158), and may best be removed by agents which specially increase the respective secretions, as common stimulants will not do. Thus mercury increases the secretion of the liver; colchicum, nitre, and other salts, with other diuretics, that of the kidneys; croton oil, jalap, sulphate of magnesia, and other purgatives, that of the intestines; and this they do, however introduced into the system, whether by the mouth, through the skin, or by injection into vessels or textures. These are important practical facts, however difficult they may be to explain; and their application to the restoration of defective secretions is sufficiently obvious.

174. But these specific stimuli of the secreting organs (§ 173), if used in excess, or too long, may not only cause general weakness, but also may exhaust even the vital powers which they first excite (§ 159): and the result may be either a diminution of the secreted fluid, or of its most characteristic constituents. Hence the long or excessive use of mercury causes torpidity of the liver; that of purgatives, imperfect action of the bowels; of diuretics, scanty, albuminous, or watery urine, defective in urea. These

facts point out the expediency of intermitting the use of such agents, and of alternating them with others calculated to improve the vital properties of the textures generally, or of employing the two classes of remedies conjointly. Tonic medicines, and such regiminal means as improve and equalize the state of the circulation (§ 124), and keep the digestive and assimilative functions in the best order, so improving the condition of the blood, are well calculated for this purpose. In illustration of the position, I may refer to the acknowledged advantage of giving bitters with or after mercurial courses; chalybeates with or after saline aperients and diuretics, when these are long used: such tonics, if used alone, or at first, check the secretion desired to be increased, but when subsequently added, they sustain it and render it permanent. Some medicines which are generally of inferior efficacy to those already named, are nevertheless better suited to improve deficient secretion in some chronic cases, because they are less exhausting, and combine some measure of tonic influence with the power of increasing the secretions. Taraxacum, preparations of iodine, sarsaparilla, and the nitric and nitro-muriatic acids may be named as illustrations of such agents. Courses of these medicines are sometimes very efficacious in keeping free the secretions after they have been restored by more powerful means (§ 173); and they likewise often improve the functions of digestion and nutrition. The salutary operation of many kinds of mineral water is dependent upon a similar principle. Saline chalybeates exercise the two-fold function of increasing the secretions, and conferring tone upon the general system; and they do this with the production of less disturbance than most medicines which act in the same way.

175. Where deficient secretions are not readily restored, the *forward* disorder (§ 168) arising from their deficiency may be sometimes temporarily obviated by artificial substitutes. Thus in defective secretion of bile, the action of the intestines may be promoted by the exhibition of ox gall. A combination of aloes and soap has been thought to supply the place of bile in some cases. Toasted bacon at breakfast bears a similar reputation; but it is probable that it really excites the liver to increased secretion, as other fat matters do: cod-liver oil seems to act upon the bowels by means of the bile which it contains. Imperfect lubrication of the throat and larynx, and other mucous membranes, in consequence of deficiency of mucus, may be remedied by mucilaginous

and demulcent matters. A dry state of the skin may be relieved by direct applications of oil, honey, or glycerine.

176. PERVERSION OF SECRETION often accompanies excess and deficiency of the process. In febrile diseases, the secretions of the kidneys and alimentary canal are altered as well as diminished. Inflammation and determination of blood, change, as well as increase the secretion from mucous membranes, rendering it more saline, and sometimes albuminous. The urine exhibits remarkable illustrations of modified quality under various circumstances: full living, stimulating beverages, and irritations of the digestive organs or kidneys, render it unusually strong and acid; low diet, and other causes of weakness, generally make it pale and alkaline. Excessive anxiety, fatigue, and mental and bodily exertion often increase the proportional amount of urea in urine; sometimes causing the deposition of the phosphates; a result of the increased decay of the tissues. Out of these morbid conditions may arise various further decompositions, leading to the deposit of sediments and calculous concretions of different kinds (§ 51, 53). In febrile diseases there is commonly an augmented quantity of uric acid in the urine. This is probably because there is then increased decomposition of tissue, but at the same time incapacity to perform the ordinary processes of oxidation by which uric acid is converted into urea. There is therefore then comparative deficiency of urea, and excess of uric acid. Oxalic acid is sometimes present in the urine on account of the morbid performance of the ordinary retrograde transformation of the tissues; especially in low febrile or cachectic states in which it replaces lithic acid, but its *strong* affinity for lime makes it always appear in combination with that base. Oxalate of lime sometimes appears in the urine after an abundant deposit of lithic acid. The disappearance of the chlorides from the urine in pneumonia is an interesting fact, well established by the observations of Redtenbacher and Dr. L. Beale. It takes place especially during the progress of the inflammation, and seems to be clearly traced to the retention of this saline matter in the inflamed part (*Med.-Chir. Trans.*, 1852, p. 325). Concretions sometimes result from an altered state of the bile. The alvine secretions are greatly modified by various febrile and the cachectic diseases, being altered in colour, and becoming unusually offensive in odour. The perspiration is also sometimes modified; thus it is

very acid in rheumatism, and fœtid in some fevers, and in delirium tremens.

177. Secretions which serve particular purposes, become unfit for their offices when they are altered, and thus cause disorder: a thin acrid mucus irritates, instead of protecting the membrane which secretes it, as in coryza and mucous diarrhœa; a viscid dry mucus clogs up and obstructs tubes which it was intended to lubricate; altered gastric juice causes indigestion; sebaceous matter of the skin accumulates in the follicles when thickened, and thus causes irritation and inflammation, &c.

178. The appropriate *remedies* for perverted secretions (§ 176) are usually such agents as likewise increase secretion (§ 172, 173). Thus depraved secretions of the intestinal canal are often satisfactorily altered by continued purging; a turbid state of the urine is sometimes removed by diuretics; too thick a state of the mucus of the air-passages is modified by expectorants, &c. But when the change depends on altered circulation in the part, the remedies must be chosen accordingly. In some cases, tonics restore a healthy state of the secretions; and in most instances of long-continued perverson, tonics may be advantageously combined with medicines which increase secretion (§ 174). Such a combination is presented in most of those remedial agents which have obtained the appellation of *alteratives,* and which therefore would be especially suited to correct the diseased condition under consideration, if they really possess the properties that are ascribed to them.

An accurate knowledge of the nature of an altered secretion often guides to the selection of the appropriate remedy for the disorder. Thus diarrhœa with a very sour state of the evacuations may be in some degree corrected by the administration of magnesia and other antacids, combined with purgatives. But as bile is commonly deficient in these cases, mercurials may be usefully added to the treatment. Antiseptics, such as chlorine, nitro-muriatic acid, and creosote, are serviceable where there is extreme fœtor of the dejections; but as in these cases there is usually some cause of quickened decay and decomposition acting on the system (§ 171), this should be looked for and removed or counteracted. Urine turbid from the presence of the lithates is most readily cleared by the alkaline diuretics; that cloudy with phosphates, by acids such as the nitric and benzoic. The viscid mucus of bronchial congestion is often connected with a gouty diathesis, and yields to alkalies combined with

iodide of potassium, squill, or colchicum. An inspissated condition of bile, leading to the frequent recurrence of jaundice, is in some cases removed by the use of hydrochlorate of ammonia, taraxacum, or guaiacum, and in other cases by cod-liver oil.

Nutrition is effected by means of a species of secretion (§ 158); but inasmuch as its operations cannot be understood without a previous knowledge of the blood and its constituents, and inasmuch as they involve the complex subject of structural disease, their consideration is best deferred.

SECTION VII.

DISEASES OF THE CONSTITUENTS OF THE BLOOD.

179. The pathological elements (§ 107) hitherto considered are alterations in the vital properties of the elementary solids. We now proceed to examine the morbid changes of the blood. These (as in the case of the solids,) may often be traced to the component elements of the blood, and they are properly included in the present division, as they must be viewed in the light of *ultimate* elements of disease. But as the blood also operates as a whole, compound in itself, although simple in its influence on vital functions and structures, it forms a proper connecting link between *ultimate* and *proximate* elements of disease. So, also, inasmuch as it is, in some respects, an organized compound, whose materials are changed, together with its functions, and which itself contributes to the production of alteration of structure in the solids of the body, the consideration of its changes will be a proper introduction to that of modifications in the circulation, which in their turn induce changes of structure, and thus lead to structural diseases themselves.

180. We have found that blood is the support of all the vital properties; and in describing their variations, we have been obliged to refer frequently to differences in the supply or quality of this fluid, both as causes and as consequences of these variations, (§ 113, 127, 131, 159, &c.) We have now to examine the properties of the blood itself, and, first, those which are most elementary, or referable to its respective constituents.

181. The circulating blood consists of red and colourless *corpuscles*, and of the *liquor sanguinis*, in the proportion of about 512 parts, *by volume*, of moist corpuscles, to 488 parts of liquor; a variation to the extent of 40 parts on either side of the 512, being, however, perfectly compatible with the state of health. But the liquor sanguinis is itself compound, both as regards its constitution and its function. Hence several of its ingredients need to be separately specified. The average proportions of the chief constituents of the blood are *by weight*, according to Lehmann, and the views adopted by Dr. Carpenter—corpuscles (consisting of hæmatin, globulin, and cell membrane) 149½ parts, fibrin 2 parts, albumen 39½ parts, fatty matters 2 parts, salts and mineral substances (exclusive of iron) 8½ parts, extractive matters 3 parts, and water 795½ parts. Hence the following blood-ingredients have to be brought separately under consideration, as agents in the production of disease.

1. Red corpuscles,
2. Colourless corpuscles and fibrin,
3. Albumen,
4. Fatty and other combustive matters,
5. Saline and mineral matters,
6. Water,

} in excess, in defect, or in altered state.

RED CORPUSCLES.

182. The red corpuscles seem to constitute that portion of the blood which possesses calorific and vivifying power, for Prevost and Dumas found that animals bled almost to death could be restored by injecting into their veins a mixture of red corpuscles and serum, even when the fibrin was absent; but the serum alone failed to produce a like effect. Hence it is inferred that it is the red corpuscles that are mainly of service when transfusion is performed in cases of hæmorrhage. Andral, Gavarret, and Delafond remarked that the vigour and beauty of domestic animals are in proportion to the quantity of red corpuscles contained in the blood, rather than to that of any of its other elements, and that when the characters of any breed are improved by crossing, the proportional amount of the red corpuscles is increased. Liebig believes that the red corpuscles serve to carry oxygen through the system, and to bring it to act on all the various textures. There is no doubt that the red corpuscles do contain a large proportion of the gases present in the blood. Van Maack and Scherer have proved that their fluid contents possess a peculiar absorbent power over oxygen.

183. The red corpuscles of the blood are formed of delicate hollow films of a fixed albuminous substance, containing in the interior cavity a liquid composed of two peculiar azotized principles mingled together. These principles are known to the chemist as globulin and hæmatin. The globulin is seventeen times more abundant than the hæmatin, and is merely albumen very slightly changed by the influence of the cell film as it passes through. The hæmatin is a more highly animalized principle of a red colour, and contains a remarkably large amount (7 per cent.) of iron. It is now generally considered to be the material especially prepared by the blood cells for the nutrition of the muscular and nervous tissues of the frame. Globulin and hæmatin seem to hold the same position in blood-corpuscles that albumen and fibrin do in the blood liquid. The red corpuscles appear to contain the principal part of the phosphorus, fat, and potash salts that are employed so largely in the construction of the nervous and muscular fabrics. Their proportion to the other constituents of the blood varies in different cases, even in health. According to Andral and Gavarret the variation extends, either way, from 110 to 152 parts in the thousand. The proportion is generally from 1 to 2 per cent. less in healthy females than in healthy males. It is greater in early adult age than it is at still earlier, or at later, periods of life. More red corpuscles are present in fœtal than in the maternal blood (according to Denis, in the ratio of 222 to 140), and this preponderance is retained for some weeks after birth, until, in fact, the blood becomes more watery.

184. *Excess of the red particles* might therefore be expected to cause a general excitement of the vital properties of the body (§ 183), and this is found really to be the case. Lecanu observed that the red corpuscles exist in larger proportion in persons of sanguine temperament, especially in vigorous constitutions, than in others. Andral and Gavarret detected a slight increase of them in the early stage of inflammation and fever, in some cases, especially in eruptive disorders, such as measles and scarlatina. In sanguineous plethora and in hæmorrhagic diseases before much blood was lost, they were in excess, in some instances rising to 185 parts in 1000 of blood. The obvious sign of the abundance of red particles is the florid colour apparent in the lips, cheeks, gums, and other vascular parts; the deep blue colour of the superficial veins; and the fine deep crimson which a thin film of blood gives when

spread on a white plate. The bodily functions, animal heat, and muscular irritability are in an exalted state, bordering on or passing into febrile excitement. Judging by these indications we may often infer the existence of an excess of red corpuscles in those accustomed to good living, and such an amount of exercise in the open air as suffices to keep the digestive and assimilative functions in an active state.

185. The *red corpuscles are deficient* in persons of the lymphatic or leucophlegmatic temperament (§ 40); after great losses of blood (artificial or from disease); in chlorosis, and in other anæmic states, such as those connected with advanced stages of cancer, diabetes, scurvy, and other cachectic diseases; in scrofulous and tuberculous diseases; in the latter periods of fevers, and after severe inflammations; in granular degeneration of the kidney, and other organic diseases, especially when attended with dropsy; in diseases of the spleen, and others of malarious origin (§ 85); in cases of slow poisoning with lead; and in persons inhabiting dark and ill-ventilated abodes. In an extreme case of chlorosis, the proportion of the red particles was found by Andral reduced to 27 in 1000 of blood.

The signs of the defect are, paleness of parts naturally coloured with blood, pallid or sallow hue of the skin, pink colour of superficial veins, and a pinkish or light purplish hue of a film of blood spread on a white plate. The symptoms of such a condition will be more fully described under the head of anæmia; they pertain chiefly to a weak state of the functions generally, comprising those of circulation, calorification, digestion, and nutrition.

186. *Alterations in the condition of the red corpuscles* are evinced by changes in the colour of the blood, and in the form of the individual corpuscles as seen by the microscope. *The colouring matter* is evidently *altered* in some diseases, being much darker than usual, as in the worst forms of scurvy, in which the blood is said, by Mead, to be changed to a dark brown or green colour: in the Walcheren and other malignant fevers it has been described as pitchy black. In the worst forms of cachexia (or rather *cachæmia*), from malarious influence, generally found in conjunction with disease of the spleen, the blood is not only very poor, but also perverted in constitution, exhibiting various shades of purple, brown, and even greenish colours. Some change seems to occur in congestive typhoid fevers, in which the blood-vessels become stained

or dyed of a deep claret colour: for this staining implies a breaking up and unnatural solution of the red corpuscles. Probably the occurrence of petechiæ and ecchymosed patches in these diseases is partly dependent on a similar change. The readiness with which the textures become stained in scorbutus, in jaundice and albuminuria, and in secondary syphilis, seems to indicate an altered state in the colouring matter of the blood; inflammations and ecchymoses in the skin are commonly followed by livid, purple, or copper-coloured stains. The yellow tinge of the skin in yellow fever, occurring chiefly along the course of the large blood-vessels, the peculiar sallowness connected with diseased spleen and in chlorosis, and the dark discoloration around the eyes in the same diseases, apparently proceed from a change in the colouring matter of the blood, which causes it to escape from the vessels and tinge the skin, as in a part discoloured by a bruise. The black matter of melanosis seems to be the colouring part of the blood in an altered state, constituting a peculiar pigmentary matter: it is likewise so in the spurious melanosis of the intestines.

187. Besides changes effected in the colour of the blood, the red corpuscles are subject to alterations in their form, size, and other properties effected through the influence of the medium in which they are placed. It was first observed by Hewson, that pure water causes them to swell, become globular, and burst; whilst saline solutions, containing more salts than serum does, make them shrink in size. These changes are now generally understood to arise from endosmosis and exosmosis: the saline matter drawing the water into or out of the little cell, which with its contained colouring matter, constitutes the red corpuscle. It is highly probable that similar changes may take place in the living body, when circumstances greatly alter the proportion of saline matter and water in the blood. Such changes may possibly contribute to produce the serious symptoms, and even the sudden death, which have ensued on drinking a large quantity of water after great exertion. Has it also aught to do with the reaction and irregular excitement that sometimes occur after excessive losses of blood? Or with the symptoms of suffering which animals manifest on the instant when water is injected into their veins? Dr. Owen Rees has suggested that the remarkable diminution of the blood discs in cases of albuminuria may be due to their destruction in consequence of the draining away of albumen from the blood, and its

subsequent reduction to a very watery state; the same circumstance may also prevent their redevelopment from the chyle and lymph both in these cases and in chlorosis. In several cases of Bright's disease of the kidney I have observed the blood discs to be jagged or crenate at their margins, and otherwise imperfect; and the same remark has been made by Simon of Berlin and others, and by Andral in a case of chlorosis. In one fearfully rapid example of albuminuria, which proved fatal in six days, with effusion of pus in the joints the day before death, I found the colouring matter dissolved in the blood-liquor after death, and scarcely any red discs remaining. There were also numerous pus globules in the blood. A similar total destruction of the blood discs was observed in University College Hospital in the blood of a person who died of malignant scarlet fever with purpura. I have met with similar proofs of breaking up of the red particles, but to a much smaller extent, in acute purpura connected with jaundice, and in cases of disturbed function of the liver without jaundice. Is this due to the remarkable solvent power which small proportions of bile exert over the red particles, as noticed by Simon and others?

188. The change of the blood from dark to florid, on the addition of saline matter, appears to depend on the increased density and white opacity then given to the corpuscles, whereby they are rendered less transparent and more abundantly reflective of light.* Probably the action of oxygen in reddening venous blood is of a similar character, for it also renders the blood less transparent. This explanation of the colour of arterial blood was suggested to me by some experiments which I made in 1835, and in some measure corresponds with the opinion of Dr. Wells,† that the brighter colour is due to fine mechanical division. Dr. J. Davy, in 1838, expressed a like conclusion. Mulder's notion, more recently advanced, that the florid colour of the arterial blood is caused by the formation of a film of deutoxide of protein on each corpuscle, is in accordance with this explanation as regards the influence of oxygen, but it hardly meets the case of the more rapid and complete brightening of blood by saline matter. Dr. Carpenter suggests that the brightening of blood may be due to the corpuscles becoming more empty and therefore assuming the biconcave form, whilst the darkening depends on their swelling to

* Medical Gazette, Sept. 1835. † Phil. Trans. 1795.

a more globular shape. Still it is the change in density rather than change in shape that would alter the reflective power. I have noticed that the dark fluid blood found in the body during malignant scarlatina, and other bad congestive fevers, does not redden so soon as usual on exposure to the air. The same remark applies in some of the other cases of alteration of the red corpuscles mentioned above (§ 187).

189. The red corpuscles are distinct structures, living cells, isolated and floating in a lifeless fluid. Like other living cells, they appear to possess the power of secretion. They certainly form the red colouring principle and the globulin which they contain. It has been conjectured that they have yet other vital properties, such as spontaneous motion, and the power of attraction and repulsion; but there are no unequivocal facts that can support such notions. The motions described by Treviranus, Schultz, and others, may be accounted for on purely physical principles. It is said, that a systolic and diastolic movement in blood particles has been observed by Dr. Martin Barry in the Fallopian tube of a recently impregnated rabbit; but this seems to have been effected by the cilia of the membrane.

190. Hewson, Prevost, Dumas, and others, observed that the red corpuscles of new-drawn blood cohere together in piles or rouleaus. This cohesion in healthy blood is of very short duration: for it may be seen, as first remarked by Dr. Hermann Nasse and Mr. Wharton Jones, that in a few seconds the adherent discs float about loosely among each other again; but in blood drawn from a person affected with inflammation, this cohesion takes place more readily, is more firm, and lasts for a longer time; it has been considered that this is the chief cause of the separation of the red particles from the fibrin, which then constitutes the buffy coat. We shall notice the relation of this phenomenon to the formation of the buffy coat under the head of *fibrin;* but for the present we would remark of it that it is not certain that the cohesion of the red corpuscles is more than a case of mechanical aggregation modified by changes in the relative dilution of the liquor sanguinis, and the contents of the blood corpuscles. The momentary exposure of a thin film of blood to the air causes evaporation from the serum without affecting the contents of the blood corpuscles as instantaneously; these then cohere; but the

exosmosis of fluid from their interiors soon again detaches them from each other.* Without however dwelling on this, or the equally hypothetical notion that the cohesion is due to a vital attraction, we may remark that it is important to bear in mind what has been stated to occur where inflammatory disease is present. Indeed it has been supposed that a similar aggregation of the blood corpuscles then takes place within the capillaries, and is the cause of the obstruction there. But although the blood corpuscles are sometimes seen to aggregate in masses within the larger vessels of a frog's web, when the motion of the blood is arrested by pressure on a vein, this aggregation is speedily broken up when the obstruction is removed; and the more permanent accumulations in the vessels of an inflamed part will be hereafter shown to be, sometimes at least, due to obstruction set up by the colourless particles, and their adhesion to the sides of the vessels. (See Inflammation.)

191. There is still much doubt concerning the manner in which the red corpuscles originate. During early embryo life they unquestionably multiply by a process of subdivision. Each then contains a nucleus cell, which parts into two, a new corpuscular vesicle being then developed round either half. In more mature life this process of multiplication by division does not seem to be continued. There is no nucleus whatever in the completed adult red corpuscle of the human blood. The red corpuscles appear to be then formed out of the chyle and lymph globules, through some unknown course of transmutation. Mr. Paget believes that he has

* Hence, as it has been remarked by Mr. Gulliver, the addition of a little salt prevents the cohesion of blood discs. I do not assert that there is nothing vital in these properties exhibited by the organised parts of the circulating fluid, but I must protest against the hasty assumption made by some physiologists, that the motions and alterations revealed in animal and vegetable fluids by the microscope are all dependent on a mysterious vitality. If any microscopical observer will take the trouble to watch the behaviour of a light flaky precipitate recently thrown down from a solution in water and spirit, he will see motions and aggregations as remarkable as those of the recently effused blood discs, although less regular, from the unequal size and shape of the particles. The close and orderly arrangement of the blood discs is favoured by their mobility and flatness, which facilitate the operation of the aggregative force; and in this respect they contrast with the white globules, whose globular shape and larger mass render them less apt to coalesce; these however often form centres, around which rolls of discs cluster in circles or rays. It is remarked by Mr. Gulliver, that the elliptical blood corpuscles of reptiles and camels cohere together in irregular heaps, devoid of the rouleau arrangement seen where round discs are concerned; it is therefore highly probable that the cohesion is due to some mechanical influence.

seen colourless corpuscles change into coloured ones; but there is a higher probability in the notion that the coloured and the pale corpuscles are independent formations, designed for distinct offices, but both originating in a common source, the chyle and lymph globule. The development, growth, and decay of the red corpuscles go on simultaneously and indiscriminately in all parts of the circulation, but are in a great degree dependent on the active state of the organs of nutrition, as well as on that of the great depurative organs (the lungs, liver, and other glands), and on a due supply of the ferruginous element that enters so largely into their composition.—(*Dr. Mann*).

The influences which promote the decay and retard the formation of the red particles (§ 185, 186), are chiefly circumstances which impair the nutrition of the body; but there are some of these which affect the red particles much more than they do other components of the frame. Two of the most remarkable are a diseased state of the spleen, and disordered uterine function. The striking pallidity, or pale sallow hue, of persons who have been long suffering from malarious influence, particularly in warm climates, has often attracted attention; it is now generally considered that these are cases in which the spleen has become diseased, an acknowledged result of the continued operation of malaria. The general state of the blood in these affections has been already noticed (§ 186); and it may now be further explained that a diseased spleen operates not only by withdrawing from the circulation an undue proportion of blood, but also by keeping it in a stagnant state, unrenewed and unpurified through circulation and excretion; it *spoils* the blood itself, and renders it unfit for further use. Hence, when in lapse of time portions of this spoilt blood are again returned into active circulation, they corrupt and contaminate the whole mass, and induce the various kinds of cachæmia or cachexia which form the sequels of malarious diseases. This view accounts for the fact, often considered unintelligible, that such morbid effects result only from enlargements of the spleen, and not from its entire obliteration, which last has been repeatedly noticed to occur without the production of any peculiar effect on the blood. Other instances of a similar character will be mentioned under the head of *congestion*.

The mode in which amenorrhœa tends to impair the quality and quantity of the blood corpuscles may also derive some light from

the foregoing remarks. A young female, during or before menstruation, is exposed to continued cold, or to sudden mental excitement; the discharge is checked; and if no serious illness immediately ensues, she begins to fail in strength, and in a few weeks or months becomes chlorotic. The uterine system remains congested after the repression of the discharge; and the blood in the system suffers, not only from the interruption of the process of excretion (M. Gay Lussac and Andral have proved menstruation to be such, for during the flow the quantity of carbonic acid exhaled by the lungs is much diminished) (§ 170), but also from the influence of a reservoir of the impure blood which tends gradually to derange and contaminate the whole mass.

192. *Remedial measures.*—Excess of the red corpuscles may be speedily removed by bloodletting, for they are diminished in quantity by the employment of such means much more rapidly than the other constituents of the blood. Low or vegetable diet, and the antiphlogistic regimen generally, including the avoidance of all stimulating or exciting agents, produce a similar effect, although more tardily. It is not certain whether any medicines produce the same result by direct influence; but cholagogue purgatives, and the continued use of mercury, colchicum, and other medicines which largely increase the excretions (§ 173), ultimately reduce the proportional amount of the red corpuscles. The dark green evacuations produced from the bowels by the continued action of calomel, and other preparations of mercury, appear, from the observations of Dr. Golding Bird, to consist of altered hæmatin. This operation of calomel may therefore be well considered as closely allied to bloodletting. Mineral saline waters, and saline medicines taken copiously and in a state of much dilution, sometimes diminish extreme rubicundity of the surface in so remarkable a degree as to suggest the notion that when absorbed into the mass of the blood they may directly destroy some of the red corpuscles; they are therefore useful cooling agents where these are in excess. The remarkable pallidity which accompanies the occurrence of extensive suppuration would also point to the formation of pus as a means for diminishing the red corpuscles; and this formation may be artificially effected by the employment of setons and suppurative counter-irritants.

193. As regards the *increase* of the red corpuscles, when in *deficient quantity*, it might be expected that nourishing food, and

especially the free use of brown meats, exposure to invigorating air and light, and the employment of tonics generally, would be the proper means to promote it. But without the teaching of experience we could never have anticipated that medicines containing iron should possess such remarkable efficacy as we find to be the case in relation to this element of disease. In many cases of chlorosis, under the use of any suitable preparation of iron, the complexion will change from waxy to ruddy, in three or four weeks' time. In the choice of the preparation of iron best suited to accomplish this purpose we must be guided by the state of the stomach and other considerations, but the most soluble preparations are the most effectual when they can be borne; and this is of more importance than the particular combinations in which they are administered: thus the iodide, sesqui-chloride, sulphate, citrate, acetate, and acid phosphate, are all severally eligible. This subject will again come under consideration in connexion with anæmia.

It has been supposed by Dr. Stevens that saline medicines have great power in restoring to their healthy state the red corpuscles which are changed in typhoid and malignant fevers (§ 186); but if these remedies are beneficial in such maladies, it is very doubtful whether much is to be ascribed to this mode of action. It is more probable that the good results from the removal of the diseased corpuscles out of the system through increased excretion (§ 192), at the same time that fresh corpuscles are produced by the influences suggested above. Thus in malarious and anæmic cachæmia, the best effects result from the combined use of purgatives, diuretics, and chalybeate tonics. Hence the advantage accruing from the operation of saline chalybeate waters, which promote the elimination of decayed blood, at the same time that they promote the formation of more of a better quality.

The disposition of the red corpuscles to coalesce, which is augmented as we have seen in inflammation, is diminished by the addition of saline matter to the blood; and Mr. Gulliver has surmised that a part of the useful operation of saline medicines in inflammation may be due to this cause.

SECTION VIII.

FIBRIN AND WHITE CORPUSCLES.

194. Fibrin and albumen cannot be distinguished from each other by difference of chemical composition. Liebig maintains that they are chemically identical; but Dumas considers that fibrin has rather more nitrogen in it than albumen. Fibrin is, however, characterised by one peculiar property, of the utmost importance in its physiological and pathological bearing—its readiness to become organized. For a long time it has been considered to be the organizable material of all the tissues in its final stage of preparation, and just about to become organized. Now, however, it is known that it is only the fibro-gelatinous textures of low vitality that it forms. Its own high organizable power peculiarly fits it to become the material of structures that have little formative strength in themselves. But, besides furnishing the substance out of which the fibro-gelatinous tissues are made, fibrin serves the highly important office of conferring certain physical properties upon the blood, that are necessary to it as a circulating fluid. A slightly viscid fluid moves more readily in narrow tubes than water itself, but at the same time it is less prone to escape through the minute pores in the walls of the containing tubes. The fibrin present in the blood guards against the occurrence of too ready transudation and hæmorrhage, and leads to their limitation within safe bounds when accidental openings of escape are made.

Being the constituent then which confers coagulability on the blood, in all the varieties which that process exhibits, and which furnishes coagulable lymph, it becomes a very important agent in the maintenance of health or the production of disease. Although probably not so immediately concerned as the red corpuscles in sustaining the vital processes of respiration, circulation, and innervation, its presence is nevertheless essential to the active state of these processes, as well as to that of the nutritive and reparative function; and it therefore exists in larger proportion and higher perfection in arterial than in venous blood. Although, as above stated, it is distinguished from albumen less by chemical differences than by its ready organizability and susceptibility of life, yet there are certain conditions, chemical as well as physical, which

are favourable to its formation, and by knowing these we are able to influence its production at will.

Fibrin, as presented to us in washed clot, coagulable lymph, or the buffy coat of inflamed blood, consists of a mass of extremely fine fibres, containing scattered among them transparent granular bodies, some separate and others in round encysted clusters. In fluid blood we see the same granular bodies or pale corpuscles, but none of the fibres. The capability of forming these *fibres* seems to be the great characteristic of fibrin, and its power to assume this fibrous state distinguishes it from albumen, which solidifies in a granular mass. So long as fibrin remains dissolved, as in the blood liquid, it is in no way distinguished from the albumen with which it is combined, but it even then has the inherent capacity to solidify in a peculiar manner. This capacity, from the time of J. Hunter to the present, has been generally considered to be an attribute of indwelling life: undoubtedly it is connected with vital activity in the sanguiferous functions; but various facts, particularly some pointed out by Dr. Buchanan of Glasgow, and Mr. Gulliver, show that the fibrillation of fibrin, like the crystallization of a salt, is promoted by, and sometimes even dependent on, the presence of fibrin already solidified, of the pale corpuscles, or of some other kindred matter. Exposure to the air, and dilution with water, also favour the consolidation of fibrin. The former is probably essential to the result; for the circumstances which promote the formation of fibrin in the blood generally include a certain degree of increased oxygenation. In fact, according to Mulder, fibrin is chemically an oxyprotein, or more definitely, the deutoxide of protein, and that its formation is in part at least dependent on the process of oxydation is probable from the fact that arterial blood contains more fibrin than venous, and of a more perfectly fibrillating and contractile quality.

But while fibrin is thus viewed with regard to its mere mechanical and physical nature, we must not lose sight of the peculiar relation in which it stands to vital properties, which attach themselves to it more than to any other constituent of the blood. Its fibres and granules are the rudiments of new living textures; and while observing its mechanical construction and its chemical constitution, we are only noting the conditions which render a highly animalized material fit for the peculiar offices of life.

The average proportion of fibrin in the blood of a healthy adult

is between two and three parts in every thousand. Within the limits of health it may vary from two to three and a half parts, being most abundant in well fed persons with active circulation during advancing growth; and least in early infancy, and in persons of weakly constitution and advanced age. It has been frequently observed that a greater number of colourless corpuscles are present whenever the fibrin of the blood is in marked excess. This has led some physiologists to adopt the view that fibrin is formed through the agency of these bodies; that indeed the main office of the colourless corpuscles is to transmute crude albumen into plastic fibrin. By others it is deemed more probable that the colourless corpuscles do, for the other albuminous textures, what the red corpuscles do for muscle and nerve, that is, prepare the material especially suited for their nutrition. Practically it is quite impossible to separate the fibrin and the colourless globules, and hence all estimates of the quantity of fibrin include the colourless corpuscles present, whatever the amount may be. Dr. Carpenter remarks that in a general way the colourless corpuscles may be deemed to be superabundant in comparison with the fibrin, when a bulky clot is of loose consistence and easily broken between the fingers, and the converse when it is very tenacious and firm. I have found the corpuscles always abundant in the fibrin and coagulable lymph of scrofulous subjects.

195. An *excess of fibrin*, and of colourless corpuscles (hyperplasma, or hyperinosis), exists in all true inflammatory diseases, especially those of a sthenic character, and in young subjects, and in acute rheumatism. In some cases of pneumonia and rheumatism, MM. Andral and Gavarret found the proportion as high as 13·3 parts in a thousand. It is stated by them that inflammation never occurs unless the fibrinous constituent of the blood amounts to five parts in a thousand. So likewise whenever an inflammation supervenes in the course of another disease, there is always an augmentation in the quantity of fibrin in the blood. The proportion of fibrin is also increased during the latter months of pregnancy.* MM. Andral and Gavarret observed an increase of fibrin in tuberculous diseases, in which we have noticed that there is a deficiency of red particles (§ 185). In one case of phthisis, Popp found the proportion of fibrin to amount to 10·7 parts in the thousand.

* In domestic animals the proportional amount of fibrin is diminished before, and increased after, parturition. (Ann. de Chim. 1842).

This result is now generally attributed to the inflammatory action that is induced around tubercular deposits. Mr. Gulliver has observed the increased quantity of white globules in blood drawn in inflammation, and I have noticed this as occurring within the vessels. (See Inflammation.) It has been supposed that the increase of fibrin in inflammation may be due to the accelerated movements of circulation and respiration, which might augment the changes of the blood in the lungs; and in some experiments by Dr. Gairdner, an increase of fibrin was produced in the blood of rabbits by making them breathe pure oxygen, or by exciting the respiration by galvanism. But it must be remarked that the amount of fibrin in inflamed blood is by no means in proportion to the frequency either of the pulse or of the respiration. There are other diseases, chlorosis for instance, in which blood drawn exhibits a fibrinous or buffy coat, without there being any absolute increase of the fibrin: this will be noticed presently. This is observed in various states of atrophy and cachexia, whether connected with deficiency of blood, defective powers of digestion and assimilation, or excessive expenditure of the nutrient fluid. An excess of fibrin, and still more so of the white corpuscles, has been noticed to exist in certain cases of anæmia, generally in connection with enlargement of the spleen, liver, and lymphatic glands. The predominance of the pale corpuscles has led Professor J. Hughes Bennett* to coin the word *leucocythæmia* to designate this affection: its true pathology remains in obscurity; but it is probably a disease of the cell-formation of the blood, in which, instead of normal red corpuscles, cells are produced without colouring matter, and advance no further. Three cases of this kind, which have recently fallen under my observation, derived no advantage from the use of ferruginous medicines.

196. *Deficiency of fibrin* (hypinosis) is of frequent occurrence in many diseases, and temporary conditions bordering on disease. Its sign is fluidity, or imperfect coagulation, of the blood after it is drawn. As venous blood contains less fibrin and of a less perfect quality than arterial, so the quantity is absolutely diminished when the blood is more venous than usual, as in cases of asphyxia or impeded breathing; and in those of cyanosis, in which the venous blood becomes mixed with the arterial in consequence of the existence of an unnatural opening. Excessive bodily

† Edinburgh Monthly Journal. 1851.

fatigue more or less expends the fibrin: hence the blood often remains fluid in animals hunted to death (§ 65). It was stated by John Hunter that the same thing may be observed in animals killed by lightning; but Mr. Gulliver has shown that this is not generally the case. In many instances the blood is found fluid in cases of death from poisoning and other suddenly acting influences. In some of these the deficiency of fibrin may be attributed to impeded respiration, which is the immediate cause of death. This is the case when poisonous doses of hydrocyanic acid, opium, and strychnia are taken, when apoplexy occurs, and when the pneumogastric nerves are divided (Dupuy). There is, however, some uncertainty about these facts. (See Mr. Blake's experiments mentioned further on.) In other instances,—as in poisoning with arsenic, sulphuretted hydrogen, and some other pernicious agents,—the fluid state of the blood must be ascribed to a more direct operation on the blood itself. So likewise in adynamic fevers, which arise from the presence of a peculiar poison in the blood, its fluidity or imperfect coagulability is one of the most remarkable conditions, and seems to be a chief cause of the hæmorrhages, petechiæ, and vibices, which sometimes then occur. In a case of very low typhoid fever, Andral found that there was less than one part of fibrin in each thousand of blood, and he states that the proportion never rises above 3·7 parts in the 1000 in ordinary continued fevers. In one instance of abdominal typhus, Simon could find no trace whatever of fibrin in the blood. The artificial imitation of this kind of fever, produced in dogs inoculated with various morbid or putrid matters, or confined over their exhalations, in the experiments of Gaspard, Magendie, Gendrin, Leuret, and Hamon, exhibited the result of a similar deficiency of fibrin in the blood (§ 194). In one case of putrid fever, Scherer observed that the deficiency was accompanied by the presence of carbonate of ammonia in the blood, doubtless the result of incipient decomposition. In the eruptive fevers the proportional amount of fibrin is not so much diminished, but neither on the other hand is it so much increased as in other inflammatory disorders. The febrile and the inflammatory condition seem to modify and antagonize each other's influence to a certain extent as regards the composition of the circulating fluid. In epidemic cholera the fibrin is invariably deficient in the blood. M. Andral also found a diminution of fibrin in cases of cerebral

congestion, with headache, vertigo, and tendency to epistaxis. In apoplexy the diminution was even more remarkable, and in one case was as low as 1·9 in 1000 during the state of unconsciousness; but on the third day, when the apoplectic symptoms were subsiding, it rose to 3·5. This rapid change seems to suggest that the oppressed state of the functions, especially of the breathing, may have reduced the proportion of fibrin.

When some neutral and alkaline salts are added to the blood out of the body its coagulating property is lessened, and it has been stated that subsisting on salted food will produce a thin or hypoplastic state of the blood during life; but this statement does not appear to be founded on any well ascertained facts, and is perhaps connected with the notions, that salt food is the cause of sea scurvy (§ 63), and that the blood does not coagulate in this disease, both of which are erroneous. (See Lib. of Prac. Med., Art. Scurvy, by Dr. G. Budd).

197. Besides the state already mentioned,—permanent fluidity or little coagulation of the blood when drawn,—a defect of fibrin in the blood causes a tendency to various kinds of hæmorrhage, generally of the asthenic kind, and to an unmanageable oozing of blood from any accidental wound or breach of texture. In a case of purpura hæmorrhagica, Routier found the fibrin reduced to less than one per thousand. Under the same circumstances, too, wounds do not readily heal, nor fractures unite. In fact, the plastic or reparative process is at fault for want of its material (§ 194); and for a similar reason, the nutrition of textures which are allied to fibrin, such as the fibrogelatinous tissues, is then imperfectly maintained.

198. Magendie found that when the fibrin was abstracted from the blood of animals, they were affected with congestions and effusions in the lungs, brain, and other organs. This he ascribed to a cause supposed by M. Poisseuille to be the expression of a general physical fact; namely, that very thin fluids pass through capillary tubes less readily than fluids of somewhat greater consistence. His experiments were, however, too rude, and his deductions too hasty, to merit confidence; the obstructions and congestions alluded to might have been due to the cohesion of colourless or red corpuscles, or even to the deposits of little clots of fibrin left by the processes employed. There can, however, be no doubt that a certain spissitude in the blood is favourable to its

transit through the hydraulic apparatus of the circulation; and that when this is deficient, various irregularities in the distribution of the fluid may occur. Some of these will be mentioned under the head of anæmia: but I may mention here that preternaturally thin blood is easily thrown into sonorous vibration, and that various unusual sounds or murmurs in the heart, arteries, and veins, may be thus produced. As these sounds are sometimes met with in cases in which the complexion does not indicate a deficiency of red corpuscles in the blood, and as they are sometimes absent in the most pallid subjects, I am inclined to connect them as much with deficiency of fibrin and albumen as with that of the red corpuscles of the circulating fluid.*

199. The consideration of *alterations in the quality of the fibrin* brings under our notice certain important morbid appearances that the buffy coat and the blood-clot occasionally present.

As the consolidation of the fibrin is the cause of the coagulation of the blood, so differences in the proportions and properties of the fibrin affect the state and appearance of the coagulum.

200. A large firm coagulum indicates an abundance of fibrin, as well as of red particles, and is commonly presented by healthy blood. A loose coagulum implies a deficiency of fibrin. A small firm clot betokens an abundant proportion of fibrin with some deficiency of red particles; but the smallness of the clot points to excess in another property of the fibrin, that of contraction during and after its consolidation. The upper part of the clot is commonly more contracted than the lower portion; it is also firmer and contains more fibrin, whilst the lower abounds more in red particles. Here there is evidently a tendency to a separation of the red particles from the fibrin. In some cases, the separation is, to a certain extent, complete, the red particles subsiding, whilst the fibrin rises to the surface, and forms at the top of the clot a layer of a light yellow or buff colour, commonly known by the name of the *buffy coat*.

It may be inferred, then, that besides *coagulation* (§ 194), fibrin possesses a property of *contraction*, and another of *separation* from the red particles. These properties are severally presented in different degrees of activity in different states of the system.

* This inference has been confirmed by the subsequent observations of MM. Becquerel and Rodier, who found that in the pallid cachexia produced by the poisonous influence of lead, the albumen is not diminished, and the vascular murmurs are not present.

Let us then consider their influence, first separately, and afterwards in mutual relation.

201. *Coagulation* is generally retarded in inflammatory diseases, and in other cases in which the fibrin is abundant (§ 195); the amount of fibrin present is indicated by the firmness and size of the clot. The coagulation is tardy also in the opposite condition, where the fibrin is scanty; but then the clot is very loose, and where the fibrin is very deficient, there may be no coagulation at all. Other circumstances may make the coagulation slow, as warmth and seclusion from the air; whereas rapid cooling, and exposure to the air (as when the blood trickles from the vein, or is drawn into a shallow vessel), hasten the coagulation. A temperature of 150° totally destroys the coagulability of the blood. The addition of some saline matters, such as common salt, nitre, or carbonate or sulphate of soda, retards the coagulation of the blood. Mr. Gulliver found that the blood of a horse to which nitre had been added remained fluid for fifty-seven weeks, yet even then coagulated, on the addition of water.

Contact with dead organic matter promotes coagulation, and most especially when that matter is at the time undergoing degradation. Mr. H. Lee* found that when putrescent pus was injected into the jugular vein of an ass, the vein instantaneously became like a rigid cord, in consequence of the deposit of fibrin within it. It is probable that pus is often shut up in the channels of the circulation, and rendered harmless, by an investment of fibrin being thrown around it. MM. Dupuy and De Blainville found that the injection of cerebral substance into the veins of a living animal caused instant death by the sudden formation of clots in the heart and large vessels.

The coagulum of the blood is dense in proportion to the elaboration the fibrin has undergone. But the specific gravity of the blood is not by any means a test of its coagulability; the heaviest blood is often that which has most corpuscles and least fibrin: the length of time that ensues before coagulation takes place, and the degree of solidification that ensues, are often in inverse proportion to each other. The last part of a stream of blood generally coagulates the most rapidly and the least firmly.

Contact with the lining coats of a living vein seems to retard coagulation, unless the vessel be in a state of inflammation. Dr.

* On the Origin of Inflammation of the Veins and on Purulent Deposits.

Carpenter represents the liquid condition of fibrin, while in the circulating blood, as being the consequence of a sort of balance of forces, the living tissues with which it is in contact tending to keep it fluid and its own plastic nature to render it solid.* It seems evident that all causes which impair the elaboration of fibrin also diminish the plastic property of the blood.

202. The *contraction* of the clot evidently depends on the attraction of the particles of fibrin for one another after the coagulation has begun. By the contraction, the red particles entangled in the fibrin are also pressed together whilst a portion of the serum is squeezed out. The more slow the coagulation is, generally the greater will be the contraction. Hence as the upper surface of the clot is often formed more quickly than the lower, it is also larger; but the central portions of the large upper layer are drawn downwards by the stronger contraction of the mass below, and in this way is caused the *concave* or *cupped* appearance in the clot, so commonly seen in buffed blood (§ 200). When blood is drawn from a vein slowly, or received into a shallow vessel, the coagulum is speedily formed in all parts, adheres to the sides of the vessel, and is not cupped. As the contraction and cupping of the clot are due to the fibrin, it might be expected, *à priori*, that these results would be marked or otherwise in proportion to the amount of fibrin present. This is the case in inflammatory diseases. But there is also great contraction, and often cupping, in chlorosis and some analogous states, where the fibrin is not absolutely increased; here the red corpuscles are so deficient, that they do not offer the usual resistance to the contractile influence of the fibrin. For a similar reason the contraction is greatest where the fibrin is most completely separated from the red particles. On the other hand, there is little or no contraction where the red particles are in great abundance, as in sanguineous plethora (§ 184), or where the aggregation of the fibrin is impaired by the addition of saline matter (§ 196). In a boy suffering from purpura, under my care, Dr. Garrod found the fibrin in the blood to be quite as abundant as usual, amounting to 3 in 1000 parts, but it was remarkably defective in the usual contractile property, and the salts of the fluid were in excess.

203. The *separation* of the fibrin from the red particles (§ 200), exhibited in the formation of the buffy coat, has attracted much

* Principles of Human Physiology, 1853, p. 184.

attention, and has been ascribed to various causes. As the fibrin always rises to the surface, and the red corpuscles as constantly sink, it is obvious that one chief reason for the separation is the greater weight of the latter. They subside entirely from the upper layer of fibrin before it has time to coagulate. Consequently this result may be favoured by four different circumstances —1, tardy coagulation of the fibrin giving more time for the subsidence; 2, increased specific gravity of the red corpuscles; 3, diminished specific gravity of the fibrin; 4, diminished thickness of the liquor sanguinis. Now two of these conditions may be produced by adding a little salt to healthy blood as it flows from the vein; and this addition really does produce a separation of the fibrin; but the fibrin then rising to the surface has neither the contractile power (§ 203) nor the firmness of the inflammatory buff; it is gelatinous like size, and resembles the sizy film sometimes exhibited in scurvy and diabetes. Further: although blood in inflammation is generally slow to coagulate, it is not so always; and in extreme cases, as in acute rheumatism, the buff appears even where the coagulation is speedy, and, according to Schroeder Van der Kolk, is seen in patches and thin films in places where gravitation could not have been operative in promoting the separation.* There must therefore be some other cause for the formation of the buffy coat, besides the one above named. The great firmness and contraction of the surface in the clot of inflamed blood may be ascribed to the increased proportion of fibrin, which is then constantly present.

204. Dr. Alison considers the separation of the fibrin in inflammation to be due to a vital repulsion acting between the fibrin and the colouring matter. Dr. Hermann Nasse and Mr. Wharton Jones think that it may be entirely accounted for by the increased aggregation (before noticed, § 190), then observed in the red corpuscles (Brit. and For. Med. Rev., Oct. 1842, p. 592). The cohesion of the red corpuscles into connected piles or rouleaux may facilitate the separation, not only by the direct influence of the separative aggregation, but also because the connected mass sinks through the liquid fibrin more quickly than separate particles would; just as bits of chalk fall to the bottom of water instead of remaining long suspended, as they would do if in the state of fine powder. Mr. Gulliver has observed that the red cor-

* Alison's Outlines of Physiology, p. 89.

puscles sink rapidly in proportion to the amount of this aggregation. Another circumstance most probably favouring the separation of the buffy coat, is an increase in its own lightness, due to an augmented proportion of fat globules mixed up with the pale corpuscles diffused through it.

205. In order that the true characters of the clot may be exhibited, the blood should be drawn by a full stream into a deep or globe-shaped basin or cup, previously warmed, and should be kept covered over until the coagulation is complete. These precautions serve to retard the coagulation, and to favour the separation and contraction of the fibrin. On the other hand, if the blood merely trickles from the vein, as when the orifice is small or the patient faint, or if the receiving vessel is shallow and cold, the blood congeals at once, and the appearance of the buffy coat is prevented (§ 202). This is one reason why blood drawn at a single bloodletting often exhibits a different appearance on being received in different vessels.*

206. The fact that fibrin exists in larger proportion in arterial than in venous blood, and that its proportional amount is diminished when respiration is seriously impeded, seems to point out that it is expended in the nourishment of certain of the textures, and that it is renewed through the agency of respiration. It might be supposed that inflammation increases its quantity by accelerating the circulation and respiratory movements without adequate expenditure of blood; but although this may be the case to a certain extent, particularly in acute rheumatism, it is not a sufficient explanation of the fact, for the quantity of fibrin in the blood is not proportioned to the frequency of the pulse or of respiration; it is often much increased before these are materially affected, and in idiopathic fevers it is diminished, although the breathing and pulse are commonly accelerated. In fact, various circumstances, to be detailed hereafter, render it probable that the increase of fibrin during inflammation has its origin in the vessels of the inflamed part.

207. The coagulation of fibrin in the blood is favoured by two circumstances, the presence of the pale corpuscles (§ 194), and the formation of the deutoxide of protein by some oxygenating process

* For much interesting information on the coagulation of the blood, the reader is referred to the edition of Hewson's works published by the Sydenham Society, with the valuable notes of Mr. Gulliver.

operating on the albumen: the same circumstances also appear to be mainly instrumental in the production of fibrin. Thus, as Dr. Carpenter has pointed out, this principle appears in the chyle of the lacteals after their passage through the mesenteric glands: it increases in the thoracic duct, and becomes still more abundant in the blood of the lungs, where there is a free supply of oxygen. It is quite uncertain how much in the process is due to vital influence, but there is good ground for the belief that some of the change is of a chemical nature. The *molecular base* of the chyle (Gulliver) supplies a congeries of minute fat globules which have a tendency to attract around them thin films of coagulated albumen (Ascherson), probably identical with *fibrin* or *deutoxide of protein*; and this process takes place in proportion as oxygen is supplied from the adjoining red blood discs; thus the molecular base is converted into single and aggregated *granules* or *pale corpuscles* of the chyle and blood. The oxygenating process extends also to the serum, and converts a small portion of albumen into an oxyprotein, still liquid, but ready to take the form of a finely fibrillated solid (fibrin), under various circumstances already adverted to (§ 194). The perfection of this material, and its susceptibility of further organization, constitute additional characters of fibrin, which appear to belong to the class of vital rather than of mere physical properties. These will be noticed in the succeeding paragraph; but we may observe here that they are in some degree dependent on the quality of the chemical materials, oil and protein, which the chyle and blood contain, and the activity of the processes of circulation and respiration, by which these fluids are constantly influenced. A further evidence of the existence of an oxidating process in connexion with an abundant production of fibrin may be found in the fact that the buffy coat of inflamed blood contains the tritoxide of protein, a soluble matter approaching in nature to gelatine, and which exists also in pus, being identical with the principle to which Güterbock gave the term *pyin*.

208. Fibrin, identical with the buffy coat of the blood, is the material of which new membranes and cicatrices are formed; it is the *coagulable lymph*, indeed, which is the plasma or basis of the constructive and reparative process. In its capacity for these processes fibrin exhibits some modifications of condition constituting degrees of plasticity. Thus in a healthy state (*euplastic*) it forms

a fine congeries of minute fibrils, which, having a high capacity for life, may become organized in a high degree, as in the case of false membranes resulting from acute inflammation in a healthy subject. But in many instances this high capacity is degraded, and the nutritive material is *caco-plastic*, with fewer and less perfect fibres, and with more corpuscles, giving the exudation more opacity, and is susceptible of only a low degree of organization, as in the indurations resulting from low or chronic inflammation, in cirrhosis, grey tubercle, &c.; or it is *aplastic*, not organizable at all, abounding in degenerating corpuscles with few or no fibrils, as in pus, curdy matter, yellow tubercle, &c.* It is a fact of great importance, that the quantity of fibrin in the blood, and the facility with which it may be effused, are by no means in proportion to its plasticity, or capacity to become organized; thus it is abundant in the blood, and freely effused in the inflammations of scrofulous or tuberculous subjects, although in such the products of the inflammation, as well as of nutrition, are commonly caco-plastic or aplastic. The fibrin of the blood or coagulable lymph in these cases is more opaque and less elastic than in healthy subjects, and under the microscope presents a predominance of corpuscular and granular matter and fat globules, and less of the finely defined fibres and regular nuclei, as if it were imperfectly elaborated; and it therefore has a tendency to further degeneration. Even the more perfect forms of fibrin or lymph, if in a position in which their vitality is not sustained by the completion of organization, tend to degenerate, and become disintegrated into an amorphous or opaque aplastic substance (Gulliver), which appears to be of the nature of spontaneous fatty degeneration and disintegration, and which eventually may undergo a further change into fatty and calcareous matter, like other aplastic deposits. It is interesting to observe that in many of these cases the red corpuscles also are defective in quantity (§ 185); and this suggests a probable reason for the imperfection of the plasma.

209. The coagulation of fibrin is promoted by the contact and motion of a rough solid: thus by stirring fresh-drawn blood

* The varieties of lymph here described in some measure correspond with those designated by Mr. Paget as fibrinous and corpuscular. (Lectures on Surgical Pathology, 1853. Vol. I. p. 332.) Mr. Paget lays more stress on the fibrillated texture of the fibrinous kind, and the great predominance of the corpuscles in the other; but it seems to me very important to keep in view the intermediate variety, which I term caco-plastic, and which contains both corpuscles and fibres. This has its difference in its subsequent history, and comprehends the three varieties of *croupous* exudation-matter described by Rokitansky.

with a stick, the fibrin is caused to adhere in shreds to the stick. The same result is exhibited within the body by the deposition of lymph on rough surfaces within the heart and great vessels ("vegetations"), and it is probable that the fibrinous concretions called polypi, which are found after death in the heart, are formed on its irregular surfaces, when its failing motions cause agitation rather than propulsion of the blood. The cohesive property of fibrin especially characterizes it, and determines its aggregation in patches and films on the surface of membranes; where it is most plastic, it may be drawn into threads or bands.

210. *Remedial measures.—Hyperinosis* or *excess* of fibrin in the blood (§ 195) is less rapidly reduced by bloodletting and low diet, than is excess of the red corpuscles; yet these are the chief means employed for effecting the object. It would probably be found that purgatives, and other agents which much increase the more solid secretions, diminish the fibrin. A similar power has been ascribed to mercury, to alkaline salts, to iodine, and to antimony: there is a want of experimental proof in support of the notion; yet it is favoured by some analogies, and seems well worthy of further investigation.* The effect of salts and alkalies in doing the same thing was probably suggested by their property of dissolving fibrin out of the body.†

211. According to the views of Dumas and Liebig, subsisting chiefly on saccharine, amylaceous, or gelatinous articles of food,

* Dr. Karl Popp, who has made elaborate researches on the composition of the blood, infers that tartar emetic and nitre, and (in a less degree) calomel, diminish the amount of fibrin. Dr. Day in Ranking's Abstract, June, 1846.

† Mr. James Blake made many experiments by injecting various saline and other fluids into the veins, and he has furnished me with a summary of the results found in the blood after death.

The blood was found to be coagulated after the injection of the following matters:—Liquor potassæ (firmly); carbonate of potass (firmly); nitrate of potass (firmly; blood scarlet); nitrate of soda; nitrate of ammonia; nitrate of lime; nitrate of baryta; chloride of calcium; chloride of barium; chloride of strontium; sulphate of magnesia; sulphate of copper; acetate of lead; arsenite of potass; nitric acid (strongly); narcotin (firmly); tobacco; strychnia (moderately); conium; hydrocyanic acid; euphorbium; and water in large quantity.

The blood was not coagulated, or imperfectly so, after injection of caustic soda, carbonate of soda, sulphate of soda, ammonia, nitrate of silver, sulphate of zinc, sulphate of iron, phosphoric acid, arsenic acid, arsenious acid, oxalic acid, infusion of galls, infusion of digitalis, alloxan.

Some of these results are different from what might have been expected; for instance the decided coagulation with potass and its salts, especially nitre, and the fluidity with nitrate of silver, sulphate of zinc, infusion of nutgalls, which have been commonly supposed to possess a coagulating property.

must diminish the fibrin and albumen of the blood; and such food is found by experience to be the best in inflammatory diseases, in which excess of fibrin is a chief element. Is the reputed efficacy of the "cure de raisins," in tuberculous disease, connected with the absence of protein compounds in the food? Bodily exercise reduces the quantity of fibrin, and may be advantageously employed with this view in sthenic plethora and in scrofulous hyperinosis, but is not admissible in inflammatory diseases. Neither can we suggest any practicable mode of lessening the fibrin through lowering the function of respiration, on which its supply seems to depend, unless narcotics, which impair many organic functions, have some action of this kind. The known utility of opium, aconite, &c., in rheumatism and low forms of inflammation, in which excess of fibrin is a constant condition, makes this matter deserving of some research. Simon mentions one case of phthisis long treated with cod-liver oil, in which the fibrin in the blood was reduced in a remarkable degree.

212. *Hypinosis*, or *deficiency of fibrin* (§ 196), is to be remedied by assisting the functions on which the supply of the plastic principle depends,—particularly those of digestion, circulation, respiration, and assimilation,—and by avoiding its expenditure through too much exercise or other exhausting processes. If the digestive organs will bear them, meat, eggs, bread, and other articles of diet abounding in protein compounds, should be taken. The digestive and assimilative functions may be roused by stimulants, bitters, quinine, and the mineral acids; which, from their power in stopping passive hæmorrhage, in augmenting the muscular substance and strength, and in causing the healing of phagedenic and flabby ulcers, seem to have some more direct means of promoting the formation of the plasma of the blood, than by their mere operation on the digestive organs. To improve the function of respiration, besides attempting to remove or diminish any disease from which the respiratory organs may be suffering, the free access of pure cool air to the lungs should be secured. The injurious effect of exertion is exemplified in the relapses which it often induces in continued fever, where defect of fibrin in the blood is a constant condition. Fatigue of every kind, and wakefulness, should be carefully avoided, and sleep should be obtained by narcotics, if it do not come naturally. In case of deficiency of fibrin from the presence of a febriferous or putrescent poison in the system, it is not to be expected that azotized food, rest, or any other means,

can remove the deficiency, so long as the poison remains in active operation. This poison, by its septic or other analogous influence, interferes with the vital process by which the fibrin is formed. But no sooner does the influence of the poison subside, as evidenced by improvement in the symptoms, than the quantity of fibrin increases; and this faster than could be explained by any increase of nourishment taken. (Andral and Gavarret.) It would seem that the immediate effect of the presence of these poisons is to accelerate the decay of the more animalized matters of the blood, which thus speedily become resolved into urea or carbonate of ammonia (§ 196), and as we find that such septic changes are retarded by certain agents such as nitre (chlorate of potass, strong bitters, alcohol, &c.) out of the body, it does not seem irrational to suppose that similar agents may be effectual in counteracting the septic influence within the body. The beneficial operation of wine and other alcoholic stimulants, of quinine in large doses, and of medicines containing a large amount of oxygen, as nitric and nitro-muriatic acids, and chlorate of potass, in typhus fevers and other adynamic diseases, is probably connected with their antiseptic as well as with their stimulating power. The oxygenating agents might, perhaps, be more efficacious could they be more readily conveyed into the blood without irritating the alimentary canal. The administration of oxygen or nitrous oxide by inhalation suggests itself as worthy of trial for the same object.

213. Very little is known of the power of remedies to correct changes in the *quality* of the fibrin of the blood. The increased properties of separation (§ 204) and contraction (§ 203) manifested by the fibrin of blood in inflammation, are diminished by bloodletting and other antiphlogistic remedies, even more constantly than the excessive proportion of fibrin is by the same means; but they seem to be soon re-conferred if the inflammation continues. Thus, although the last cup drawn in bloodletting may exhibit none of the buffed and cupped appearance presented by the first, yet blood drawn a few hours after often shows it as much again. Knowing that this speedy recurrence of morbid properties in the blood depends on the influence of the local inflammation, we see the necessity of fully using local remedial means, together with those that are calculated to operate on the system.

The beneficial influence of saline medicines in inflammatory diseases is supposed by Mr. Gulliver to depend on their power to prevent the cohesion of the blood corpuscles, and he has hence

suggested the free application of salt lotions to an inflamed part. The application of salt to a recent wound is a well known popular remedy.

214. Bloodletting and other general antiphlogistic remedies, if they do not remove local inflammation, may render its products more injurious through lowering their plasticity (§ 211), thus approximating them to tuberculous and other aplastic deposits. Thus chronic inflammation continuing after the full employment of the antiphlogistic treatment, almost surely tends to produce degenerated changes of structure, over which remedial art has little power. Hence, therefore, we see how desirable it is that inflammations should be removed before they become chronic; and when there is a risk of their becoming so, it is an indication that we should try to improve the condition of the blood by a tonic and nutritive plan of treatment, at the same time that local antiphlogistic measures are addressed to the lingering inflammation.

215. A similar course of tonic treatment is yet more forcibly called for in scrofulous, chlorotic, and other cachectic states, in which the fibrin, although less abundant than in inflammation, is yet copious in proportion to the scanty red corpuscles (§ 212). Here there is a tendency to the deposit of imperfect fibrin and granular matter (§ 211), even independently of inflammation; and, besides means calculated to improve the nutrient functions and to raise the character of their product, it may be necessary to use remedies that tend to keep the fibrin dissolved, and to prevent its consolidation in aplastic forms. Alkalies and iodide of potassium have been supposed to have some claim to the power of doing this; but more efficacy seems to attach to regiminal and dietetic influences, such as the exclusion of all food containing solid fat and protein matters of the lower class (like casein); the freshest and most sustaining but easily assimilated nutriment should alone be allowed, and every available step should be adopted to promote the functions of digestion, respiration, capillary circulation, and excretion, through due supply of healthy air, and through the employment of exercise and frictions of the surface.

SECTION IX.

ALBUMEN.

216. Albumen is an important constituent of the blood, amounting in health on an average to about thirty-nine parts in every thousand. It was generally supposed to be chiefly useful in affording the material from which the plasma (fibrin) is elaborated; but it was suggested in the former edition of this work that some textures may be formed at once from the albumen of the serum. This opinion seems now to be the prevailing one; that the more solid tissues as well as the globulin and hæmatin are formed from the albumen, whilst the fibrogelatinous textures alone are constructed of fibrin. The albumen is further useful in giving to the serum a consistency favourable to the process of circulation; it also fits it for the suspension and preservation of the red corpuscles, and for blandly sheathing the acrimony of the saline constituents. The quantity of solid principles in serum amounts to from seventy-two to eighty-eight parts in every thousand during health, and of these four-fifths are albumen. It may be generally inferred from the specific gravity of the serum, how much albumen it contains; this in healthy subjects averages about 1030, but sometimes in disease falls as low as 1013.

217. *Excess of albumen* exists in most cases of inflammation and fever, especially during the more active stages. Its increase is not, however, in the same proportion as that of the fibrin. Its relative amount is much augmented in epidemic cholera; but this is mainly due to the removal of the water of the blood. Albumen is the principle of the blood that is least affected in its proportions by disease. Very poor living, long continued or copious hæmorrhages, and other drains on the system, will pretty surely reduce it in common with the other animal principles; but good living has less power in raising it above the natural standard. In the pallid cachæmia of persons who have suffered long under paraplegia, it has been ascertained by MM. Becquerel and Rodier that the albumen is not diminished, but is actually in excess, as compared with the other solid constituents of the blood: in fact it is not the

albumen that is absolutely increased, but the red corpuscles diminished, the albumen remaining the same.

218. The means of reducing an excess of albumen in the blood are similar to those capable of diminishing the other animal constituents (§ 192, 210), including depletion, purgatives (especially mercurial), diuretics (especially alkalies and colchicum), and low diet, with a sparing supply of azotized food.

219. *Deficiency of albumen* in the blood is most remarkably met with in cases of albuminuria, or disease of the kidney with coagulable urine; and this deficiency precedes the diminution of the red corpuscles, which takes place in the advanced stages of this disorder. Dr. Bright found the specific gravity of the serum as low as 1013 in a patient with albuminuria. (Bright's Reports, vol. i. p. 85.) Dr. Babington noticed the specific gravity of the serum, in a case of diabetes, as low as 1024; and in another as 1027, although that of the blood was higher than usual, being 1061. In this case the serum was milky. (Cycl. of Anat., &c., Art. "Blood.") Andral observed that the deficiency of albumen in the serum of the blood is in exact proportion to its excess in the urine. In their later researches, MM. Andral, Gavarret and Delafond discovered a remarkable diminution of the albumen in dropsical sheep affected with the rot (a watery state of the blood, with distomata in the liver.) Sheep in a cachectic state, with deficiency of red corpuscles in the blood, but without entozoa, or dropsy, had the albumen undiminished. It is therefore most probable that the cases of cachexia, or anæmia, attended with dropsy, owe this concomitant to a defect of albumen in the blood. It is this principle chiefly that gives the blood liquor its spissitude, which renders it more fit to pass along the vessels, and prevents it from transuding through their walls. This deficiency of albumen, therefore, seems to be a chief condition of the dropsical diathesis.

220. We are not acquainted with any other means of increasing albumen in the blood, where it is deficient, than the adoption of such measures as tend to restrain wasting discharges, and to improve the general nutrition. The excessive loss of albumen through diseased kidneys may be in some cases checked by what may be termed astringent diuretics, which are also effectual in arresting hæmorrhage from the urinary organs. Among these may be mentioned gallic acid, tincture of the sesquichloride of iron, benzoate of ammonia, and in some cases tincture of cantharides, and oil of

turpentine in small doses. In various instances I have used each of these with the result of increasing the specific gravity of the urine, yet diminishing the albumen. To counterbalance the waste by a liberal supply of nutritious food is another obvious indication; and, in addition to the ordinary albuminous articles of solid food, a sustaining beverage may be made of raw whites of eggs and water, flavoured with sugar and lemon juice. A case is mentioned by Simon (Animal Chemistry, by Day, vol. i. p. 280) illustrative of the extraordinary nutritive properties of cod liver oil in phthisis; the solid constituents of the blood after its use amounted to 25 per cent.; the albumen being above 13 of this; the fibrin, usually high in phthisis, was below the normal proportion.

SECTION X.

FATTY, AND OTHER COMBUSTIVE MATTERS.

221. The blood, in a state of health, contains three distinct kinds of fatty matters;—1. Saponifiable fats composed of the spermaceti-like substance called margarine, dissolved in olein, an oily liquid: 2. Phosphorized fats, contained principally in the red corpuscle: and 3. Cholesterine, a hydro-carbon combined with a minute proportion of oxygen, and formed in the liver. The saponifiable fats appear to be nutritious principles introduced into the blood by the chyle. The phosphorized fats are probably formed by the blood corpuscles for the especial support of the nervous substance. Both these kinds of fatty matter are necessary to the early stage of cell production. The cholesterine seems to be, on the other hand, merely a fuel furnished out of excrementitious matter for calorific purposes. It is now known that, besides these true fats, the blood also ordinarily contains sugar. This principle may always be detected in venous blood, between the liver and the lungs, but is destroyed in the lungs by the influence of the air, being in these organs converted into water, lactic acid, and finally carbonic acid. No sugar can be found in the blood of the left ventricle. Bernard has shown that it is formed by the liver, alike out of azotized and unazotized matters. Division of

the pneumo-gastric nerve, and diseases that exhaust the nervous energy, arrest its production. It is highly probable that it is destroyed in the lungs for the support of animal heat, and that like cholesterine it is a true fuel. Carnivorous creatures seem to make most sugar, and the herbivorous most fat, for the purposes of combustion.

222. The oily or fatty matter in the blood is sometimes so much increased as to give a milky appearance to the serum; and this increase may arise under different circumstances, and from various causes. The most common cause is that originally suggested by Haller, and lately proved to exist by Dr. Buchanan, the presence of unassimilated chyle (§ 211). The latter physician has ascertained that the serum is generally milky in blood drawn four or five hours after a full meal. In other instances, this appearance has been observed during illness after long fasting, and doubtless then proceeds from the absorption of fat from the textures, as supposed by Hewson. In some cases a turbidity in the serum has been found to depend on the presence of an increased number of minute granules of albumen or fibrin, soluble in acetic acid, and not affected by ether. (Vogel's Path. Anat. by Dr. Day, p. 64. Notes to Hewson's works by Gulliver, p. 85.) Dr. Babington met with an extreme degree of milky serum in a case of advanced diabetes. This physician states that he has repeatedly found milky serum to have a low specific gravity, indicating a deficiency of albumen; and he suggests that the fat might originate in a change in the albumen. A similar idea has frequently occurred to myself, when considering the remarkable instances of fatty transformation exhibited in degenerating textures and deposits, and even in slowly decaying animal matter, as in the instance of the production of adipocire. This notion has been fully confirmed by the researches of Dr. R. Quain, which will be noticed further under the head of *Degenerations*. The fat of the blood seems to vary in nature as well as in proportion; cholesterine and margarine are often found on the increase in old and cachectic persons, as they also abound in the degenerated tissues and cacoplastic deposits of such subjects.

223. The increase of healthy fat or adipose tissue in the body is probably preceded and accompanied by its presence in excess in the blood; and the circumstances which promote obesity must operate through the composition of this fluid. Of these may be

mentioned fatty, sweet, and farinaceous food in excess, yet where obvious disorder of the digestive organs is not caused; full living with sedentary habits, and especially if combined with the free use of malt liquors; imperfect assimilation, often connected with want of exercise of the respiratory organs, either from disease or disuse; insufficient excretion of bile. Exercise tends especially to reduce the fat of the body, probably by increasing its combustion in respiration; the nutrition of muscular textures being then augmented by the same influence. Thus fat commonly increases at the expense of strength, and is reduced in proportion as muscular power is restored. Besides the use of as much exercise as the strength will bear, exposure to the invigorating influence of pure air, and the avoidance of fat and similar articles of food abounding in hydro-carbon, some further advantage may be secured for corpulent persons by the employment of food and medicines, in which oxygen and azote predominate, as, for instance, nitric acid, chlorate of potass, benzoate of ammonia, and some vegetable acids.

But there is sometimes an increase of fat in the blood without any remarkable obesity; when the fatty matter is formed at the expense of albumen and fibrin by a process of degeneration, which affects not the blood only, but also the tissues under various circumstances of degraded nutrition and circulation. This fatty cachæmia may slowly result from age, debility, or various chronic cachectic diseases which impede respiration and excretion; but I have observed an acute affection of the kind to ensue in persons, young and middle-aged, who, with very intemperate habits, have endured such privations as to destroy all constitutional vigour; in cases after death, from delirium tremens, erysipelas, or some acute attack which proved rapidly fatal, the blood and all the textures have been found so abounding in fat as almost to countenance the notion that a little more of such a change might render the body spontaneously combustible. But in case of disease of the liver, the fat in the blood has been found to increase to two or three times its ordinary proportion, and it is then chiefly cholesterine. In cases of peritonitis and pneumonia also, an excess of fat has frequently been found in the blood. A remarkable case of peritonitis is described by Helder, in which the fat attained the extraordinary proportion of 50 in 1000 of serum: the red corpuscles were much below the usual standard (Dr. Day's Note to Simon's Animal Chemistry, vol. i. p. 271). It is probable that in many

of these instances the excess of fat is the result of its rapid absorption from the adipose tissue during the disturbance of the acute attack; but others are the result of an undue formation of fat, or of its insufficient combustion by the respiratory process.

224. *Defect of fat* in the blood occurs in connection with continued inanition and emaciation, especially in typhoid fevers and malignant diseases. In scrofulous emaciation the fat in the blood is not always lessened; sometimes it is increased; apparently in connection with the fatty transformations which take place in the deposits, and sometimes in organs, as in the liver. It would be interesting to know the state of the blood in those cases in which large quantities of fatty matter are discharged from the intestinal canal.

Deficiency of fat in the blood is to be obviated by the administration of such oleaginous articles as the stomach will bear (such as cod liver oil, cream, bacon, mutton suet diffused in milk, &c.) and also by oily inunctions and frictions of the surface. This subject will come under our notice in connection with atrophy. But it may be mentioned here that a knowledge of the condition in which the fatty principle best assists in nutrition in health may be useful in guiding us in the selection of the oleaginous articles of food or medicine best suited to supply the deficiency. Thus the more fluid fats are preferable to the solid, from their being more easily absorbed and as supplying finer molecules for the chyle. Again, some oils are more readily saponified than others; in this respect there is an advantage in cod liver oil, which, like the fat of bacon, readily saponifies or forms an emulsion with carbonated alkalies, which is not the case with oils or fat in general. In case of paralysis or great depression of the nervous power, it may be useful to give phosphorated oil, with the object of supplying the materials by which the nervous function is sustained. From $\frac{1}{40}$th to $\frac{1}{20}$th of a grain of phosphorus may be given in a teaspoonful of almond or cod liver oil. A diet abounding in milk and cream is also calculated to supply both oil and phosphate of lime to the blood, and has often proved beneficial in cases of atrophy; but it is remarkable how readily in some cases it arrests the secretion of bile.

SECTION XI.

SALINE AND MINERAL MATTERS.

225. Healthy blood contains, upon an average, 8 parts in 1000 of mineral substances (exclusive of the iron of the red corpuscles); these are principally in the condition of salts,—chlorides, carbonates, phosphates and sulphates of soda, potash, magnesia, and lime. The chloride of sodium is singularly constant in its proportions. The phosphates are in larger amount in carnivorous animals, and the carbonates in herbivora. Rose thinks that the phosphates are only formed at the instance of the destructive oxidation of the phosphorized fats, the phosphoric acid then taking the alkaline bases from carbonic, and the organic, acids. He holds a similar view with regard to sulphur, iron, sodium, potassium, &c., which, existing in the blood and in other animal constituents in an unoxidized state, take an important part in their metamorphoses.

The saline matter dissolved in the blood tends to preserve the form of the red particles and the fluidity of the fibrin. The phosphate of soda dissolved in the serum enables that fluid to take up twice its volume of carbonic acid (as much again as water can absorb). Phosphate of potash is devoid of this important property. It is most probable that the phosphate of potash and chloride of sodium in the blood are constantly effecting each other's decomposition, phosphate of soda being found to render the serum powerfully absorbent of carbonic acid, and the potash being employed in the construction of muscular substance. Potash is as essential to the composition of muscular tissue as phosphorus is to that of nervous matter. The earthy salts supply inorganic ingredients to the various tissues; and especially the phosphate of lime, which appears to be essential to the formation of rudimentary cells. Vogel states that the salts of the blood are in excess in scurvy, and cause the hæmorrhagic disposition in that disease; but this does not accord with what has been observed in this country (§ 196). He also thinks that the same influence renders the red corpuscles granular or puckered at their margin by withdrawing some of their fluid contents. Such a condition of the red corpuscles, as well as an excess of saline matter, was pre-

sent in the blood of a boy suffering from purpura, who was under my care a few years since.

There can be little doubt that the thirst induced by the use of salt food is connected with the excess of saline matter then thrown into the blood, which causes a shrinking in the red corpuscles, and makes them attract, by endosmose, fluid from the textures and surfaces, wherever they come; this constantly setting up fresh demands for liquid, produces the sensation that prompts drinking as the natural means of furnishing the supply.

226. Diminution of the ordinary quantity of saline matter in the blood has been said by Dr. Stevens to take place in yellow fever and in other pestilential diseases, and to cause then so dark and grumous a state of the blood, that free exposure to air will not render it florid, as it generally does. This has been distinctly ascertained to be the case with regard to malignant cholera, by Dr. O'Shaughnessy; and the defect of saline matter and water seems to be the immediate cause of the obstructed circulation, lividity, and collapse, so remarkable in the advanced stage of that terrible disease. Dr. Mackintosh found in some extreme cases that the blood was extensively coagulated in the heart and large vessels. There can be no doubt, therefore, that in these circumstances the blood coagulates in the vessels for want of saline matter, and that the red corpuscles become partially dissolved and altered. Hence the temporary efficacy of injection of saline solutions into the veins of cholera patients; it seems at once to renew circulation, respiration, warmth, and other vital functions, as if the saline solution were the only thing needed. But the defect in the blood is a result of the excessive evacuations of serum from the stomach and bowels which are the effect of the action of the poison; and if these go on, the good influence of saline injections is soon exhausted.*

* It has been stated that in many cases of malignant cholera there is little or no discharge from the stomach and bowels, and yet the symptoms of collapse proceed as usual; but so far as my limited experience has enabled me to judge, it appears to me that there is a relation between these symptoms and the loss of serum from the intestinal surface. In the worst cases, where the prostration is most complete, this serum is not evacuated, but distends the intestines, and on palpation may be felt, giving the feeling of liquid weight in the abdomen, which is remarkably dull on percussion. Doubtless the forcible and speedy discharge of this secretion is an evidence of a strong reaction, endeavouring to rid the system of the poison; and I quite agree with those who object to the practice of beginning the treatment with astringents and opium. To aid and equalize the expulsory effort by remedies which promote the biliary and renal, as well as the intestinal secretions, seems to be the

227. The researches of Andral scarcely support the notion entertained by Dr. Stevens, that the salts of the blood are deficient in typhus fever. If saline medicines are useful in common continued fevers, it is a question whether it is in consequence of their supplying what is deficient, or whether it may not rather be through the augmentation of torpid secretion (§ 171), and the removal or counteraction of septic influences present in the system (§ 98, 105). Certain it is that not only in feverish affections, but in that very numerous class in which the urine is scanty, high-coloured, highly acid, and often depositing a sediment of lithates or oxalates, and frequently the coated tongue, thirst, disturbed appetite, and depraved secretions, show the unhealthy condition of the alimentary canal. Saline solutions, especially in the effervescing state, are most beneficial and grateful, and often correct what is disordered in the secretions. In prescribing these salines, however, it is right to bear in mind the influence which they may have on the composition of the blood, and so to combine the alkalies that neither shall have a disturbing preponderance. With this view soda and potass should both be given, with the addition of ammonia if the dryness of the skin or the weak state of the circulation should indicate it. This method of combining the alkalies much increases the utility of saline medicines; but if exhibited long they have a tendency to weaken the digestive powers and to cause flatulence and distension of the abdomen. This may often be counteracted by the addition of a minute proportion of a salt of iron, which endows the medicine with a tonic property.

It is stated by Henle that a diminution of saline matter takes place in the blood of inflamed blood-vessels, but this statement seems to be no more than an assumption made in aid of his favourite explanation of the obstruction in inflammation.

first indication. But it may soon be necessary to moderate the excessive discharge and allay severe pain and irritation, sometimes by moderate but frequent doses of astringents and narcotics, but always by ice and cold beverages internally, and by heat, stimulants, and frictions very freely and assiduously applied to the surface and extremities. Whether this treatment shall prove successful or not, will depend on the intensity of the poison and the power of the constitution to resist its influence. At the outbreak of the epidemic the poison is usually so strong that the larger proportion die in spite of all treatment; as the epidemic declines, the treatment proves more successful and the plurality of cases recover. It is during the balance between the contending forces that saline injections into the veins may save life—not by curing the disease, but by counteracting its fatal effects on the blood, so that longer time is gained. This measure therefore should not supersede others, which are indicated by the symptoms of the case.

SECTION XII.

WATER.

228. The average proportion of water in healthy blood may be stated at about 79 per cent. It is obvious from what has been already said, that this proportion increases as that of the organic constituents decreases. Thus, after excessive hæmorrhage, and in chlorosis and other cachectic states attended with anæmia, the blood is more watery than usual. The effect of this state of the blood is a tendency to dropsical effusions and fluxes, besides the consequences which result directly from the relative deficiency of the other constituents of the blood.

229. I have before suggested (§ 187) the question for consideration, whether the serious functional disturbance sometimes following the ingestion of very large quantities of liquid, particularly after exertion, when absorption is active, may not in some degree arise from the too copious and sudden addition of water to the blood. Certainly temporary plethora, with palpitation, and feeling of oppression or dyspnœa, often results from the too free ingurgitation of liquid, and is not removed until perspiration, or a free flow of urine, relieves the overloaded vessels. These effects are most distinctly observed when some structural disease of the organs of circulation or respiration incapacitates them for meeting the increased task. Hence the aggravation that occurs in the symptoms of disease of the heart and lungs, when too much drink is taken. The colliquative sweats in phthisis seem to arise from a similar cause, and may often be relieved by a judicious reduction in the quantity of liquid food.

230. *Deficiency of water* in the blood is exemplified in epidemic cholera, in which the specific gravity of the serum has been found as high as 1045 (Lecanu); this implies a reduction of the ordinary quantity of water to the extent of nearly one-half. Some diminution probably takes place in other diseases, attended by profuse watery discharges, such as diarrhœa, diabetes, and excessive sweating. In these cases, the smallness of the pulse, and sometimes the shrunk appearance of the surface from the undistended state of the vessels, indicate the diminished bulk of the circulating fluid; and thirst pretty constantly points out the mode which nature

suggests as a remedy for the defect. Exposure to heat, especially if long continued, and prolonged violent exercise, expend the water of the blood, and cause the feeling of thirst which prompts to its restoration. Long continued abstinence from drink has a similar effect.

It has been already mentioned, that the extraordinary decrease of the water of the blood in malignant cholera renders that liquid so thick that it cannot circulate freely, and that this change is the chief cause of the cessation of the pulse, lividity, and other signs of obstructed circulation. No such effect is, however, known to accompany any of the other states where water is deficient. The influence of heat and prolonged exertion is complex, and therefore not referable to this principle only. Abstinence from drink for two or three days induces languor, small and easily accelerated pulse, a somewhat dry and pasty state of the mouth, and scantiness and turbidity of the urine, but little derangement of other functions. The digestive process, which might be expected to suffer, in some cases at least, shows no symptoms of disorder.

231. We thus have the power of increasing or diminishing the quantity of water in the blood by increasing or diminishing the quantity of liquid drunk; and these expedients may be usefully employed in cases such as are mentioned above. But these expedients also furnish us with therapeutic agents of more extensive power when they are employed in extremes. Drinking large quantities of water may excite the whole vascular system and its connected secreting organs, and may, in a salutary manner, wash out of the blood various effete or noxious matters; it is in this way that the "water-cure" sometimes produces its beneficial effects. The free use of liquid ingesta is supposed, by Prout, to prevent the formation of lithic acid, or, according to Liebig's views, it facilitates the conversion of lithic acid into urea. From the experiments of Dr. Böcker (Brit. and For. Med. Rev., Oct., 1854, p. 393), it is proved that large draughts of water reduce the weight of the body by accelerating the metamorphosis of tissue and in increasing its elimination through the kidneys and bowels. On the other hand, a total abstinence from drink for two or three days is an effectual mode of stopping fluxes, and of relieving catarrhal inflammations and congestions. Either plan exerts an alterative operation on the circulation and secretions, which, if more studied, may perhaps be turned to good account in the treatment of many

diseases. But their injurious effects should be held in mind: thus the "water-cure" is known to produce an eruption of boils on different parts of the body; and these, although considered by the advocates of this system as symptoms of a salutary crisis, are a serious and sometimes dangerous evil; and most probably proceed from an injury done to the blood and the nutritive function by an excess of water, which tends to injure the red corpuscles, and thus to spoil the blood, and to increase the waste of the textures. Again, the "dry-cure," by abstinence from liquids, may cause faintness and exhaustion in weakly persons, and might be hurtful in those subject to urinary gravel.

SECTION XIII.

CHANGES IN THE BLOOD BY RESPIRATION.

232. The process by which venous blood is made arterial, and rendered fit for its purpose of maintaining the life and functions of the several parts of the body, is liable to be variously modified; and the differences in the state of the blood thence resulting form important elements of disease.

The conversion of venous into arterial blood is effected by the absorption of oxygen, and the removal of some carbonic acid and water; and a slight increase in the proportional amount of fibrin is the constant accompaniment of these changes. Each of these several parts of the process is probably concerned in giving to arterial blood its fitness for its function; the absorbed oxygen, by its affinity for the hydrogen and carbon of the blood and textures, aiding in those processes by which these are renovated in function as well as in structure, superfluous fat and other combustible matters consumed, and heat evolved; the removal of the carbonic acid being the excretion of a noxious matter; and the renewal of the fibrin supplying the loss of that plasma occasioned by the waste of the fibrous and membranous structures.

233. It is doubtful whether the respiratory changes are ever carried on in *excess*; for, by an admirable adaptation, the activity of respiration is proportioned to the rapidity of the circulation and

the corresponding need of alteration in the blood.* Thus exercise accelerates the circulation and changes of the blood, and also augments the breathing movements. In fevers the frequency of the pulse and of respiration is increased; but the muscular strength being much impaired, it is doubtful whether the rapidity of the circulation or the real amount of the respiratory operations is augmented in the same proportion. It has been said, that in acute rheumatism the circulation and respiration are too active for the wants of the system, and that the blood reaches the veins without having wholly lost its arterial character. If this be a correct observation, the hyper-arterialization of the blood may perhaps account for the unusual quantity of fibrin which is present in the disease. I must, however, remark that I have found the excess of fibrin in cases in which there had been no remarkable acceleration of the pulse or respiration. We shall see hereafter that the increase of fibrin is connected rather with the local inflammation than with the fever.

234. From the experiments of the late Mr. Broughton, it appears that when animals are confined in oxygen gas, they die comatose in the course of a few hours: the respiration first ceases, whilst the heart continues to beat with vigour, and the blood, even in the veins, is quite florid: the blood also presents the arterial character of very speedy coagulation. It appears, then, that excess of oxygen injures first the nervous function (§ 154); but whether it does so by exhausting it through previous excitement, or by the increased coagulability of the blood, or by the excessive

* It seems to me that Professor Liebig has given too mechanical a view of the change of the blood in respiration. He appears to consider the increased arterialization, during exercise and on exposure to cold, to be a necessary consequence of the greater amount of air inhaled, in one case in consequence of accelerated movements of the chest, in the other in consequence of the greater density of the cold air. But if the extent of the changes wrought by respiration were in exact proportion to the quantity of oxygen received into the lungs, how easy would it be to increase them (and thereby animal heat also) by voluntarily augmenting the respiratory movements. I cannot but think that the proportion of oxygen absorbed, and of carbonic acid expired, depends more on the condition of the blood brought to the lungs, and that the respiratory movements are regulated by this. Thus the increased oxygenation of the blood is a consequence of greater changes previously wrought in the blood itself, and not a mere result of a fuller access of air. In confirmation of this view I may mention an experiment which any one can repeat; if a succession of moderately deep and quick respirations be performed during several minutes, at a pretty low temperature, the effect is to cause feelings of chilliness and faintness rather than of increased warmth and energy; it is like extinguishing a fire by overblowing it. It appears certain, however, that moderate cold to the surface of the body, as by cold bathing, increases the respiratory process; for it not only renders the respiration more frequent, but it causes more urea to pass off in the urine, which is an evidence of accelerated oxidation.

production of carbonic acid, has not been decided. The last-named mode of explanation is the most consistent with the related phenomena: it can scarcely be doubted that an increase of oxygen in the blood must augment the production of carbonic acid; and that this latter agent may asphyxiate independently of the exclusion of oxygen, appears from an experiment by Rolando: he found that the air-tube of one lung of the land tortoise may be tied without materially injuring the animal, but that if one lung were supplied with carbonic acid gas whilst the other received air, the animal died in a few hours. (Carpenter's Human Physiology, p. 542.)

235. *Defect* of change in the blood by respiration is a common and important cause of disease, and constitutes a chief feature in affections of the respiratory apparatus. Being the essence of the special disease *asphyxia* or *apnœa*, its minute consideration belongs to special pathology, and we shall here only describe it in its more general characters.

The amount of mischief arising from defective respiration varies greatly according to the sudden or the gradual supervention of the evil. An acute attack of disorder in the organs of respiration may prove distressing, and even fatal, although the impediment to the breathing is much smaller than that caused in some chronic diseases, where nevertheless, in consequence of the gradual nature of the infringement, the mischief is scarcely perceived. Thus, too, patients affected with extensive emphysema of the lungs are habituated to an imperfect state of respiration, which is shown by a constant lividity of the lips and cheek; such an appearance would be a sign of approaching death in other persons. The cause of this difference is not merely the general fact that sudden changes produce more effect than slow changes; it lies chiefly in this;—that the importance of the respiratory function varies under different circumstances. When the several parts of the body, especially the muscular organs, are in a state of full activity, more breath is needed to remove from the blood the noxious effete matter which is always produced by functional exercise. Hence in such a condition (which is that of healthy action) the respiratory process cannot be abridged without serious disorder. This disorder is first obvious in the increasing sense of oppression and suffocation which the want of breath causes, and which excites forcible exertions to breathe. If these exertions still fail to duly aerate the blood, it partly is arrested in the lungs, right compart-

ments of the heart, and veins, and partly passes in an imperfectly arterial state to the left side of the heart, and to the arteries.

236. The phenomena of asphyxia are thus compounded of—1, accumulation of blood in the venous system; 2, diminution of blood in the arterial system; and 3, deficiency of oxygen and excess of carbonic acid in the blood. These several conditions cause injury to the vital functions, both by the want of a due supply of blood, and by the bad quality of that blood, which last is injurious, — negatively through want of oxygen, the proper exciting agent, and positively from excess of carbonic acid and other excrementitious matters, which are sedative influences. The symptoms induced are also of two classes—1, those implying failure of function, such as muscular debility, feeble action of the heart, pallor and coldness of the surface and extremities, and loss of the sensory and mental faculties; and 2, those arising from congestion and the noxious influence of the black blood, such as palpitation, flashes in the eyes, noises in the ears, delirium, muscular spasms, stupor, &c. Either of these sets of symptoms may predominate in different cases, and hence a variety in the phenomena of asphyxia, which has not been sufficiently noticed by writers on the subject.

237. But we have also to notice the other mode in which the changes in the blood effected by respiration may become defective, that occurring gradually, or when the vital functions are in a languid state. It is well known that hybernating animals scarcely breathe at all, and yet live; this is obviously because their vital functions are reduced to an extremely torpid state. So, too, animals newly born will bear the privation of air for a much longer period than those which are older; it has been supposed that in adults failure of the heart's action by syncope retards the operation of asphyxiating causes. (Dr. Carpenter, on Asphyxia, Library of Med., vol. 3.) Although a man cannot be reduced to the torpidity of hybernation, yet it is certain that he may be brought to bear a defect in the respiratory blood-changes, which would be fatal in a few minutes under common circumstances. This is seen when the defect is congenital, as in those affected with malformations of the heart causing cyanosis; and it is also seen where the defect is very gradually induced, as in emphysema of the lungs.

238. In cases of cyanosis, (the blue disease, in which, from malformation of the heart, some venous blood passes into the arteries,) we have the opportunity of observing the more essential

effects of defective arterialization of the blood. Individuals thus affected are in a lower scale of animation. The processes of nutrition and secretion seem to go on pretty well, but the muscular power is low; slight exertions bring on symptoms of faintness, palpitation, suffocation, or insensibility; the animal heat is lower than is natural, and there is greater suffering from the influence of cold. In short, all the powers of body and mind are slender, and are easily disordered by circumstances that tax their activity. In the few that reach mature age, there is no sexual passion, which seems to be a happy provision against the chance of perpetuating a race of imperfect beings—human reptiles. The subjects of cyanosis are said to be very liable to hæmorrhages, and when these occur spontaneously, or from accident, it is very difficult to stop them. This must be ascribed to the deficiency of fibrin which we have already stated to occur where the changes of the blood by respiration are imperfect (§ 196). The same peculiarity occurs in the fœtus.

239. In connexion with the scantiness of fibrin in the blood, when the respiratory changes are defective, we must notice that the excessive deposition of fat, which often occurs, agrees very well with Liebig's idea that respiration directly consumes the oily parts of the blood; the respiration being defective, the fat accumulates (§ 224).

Liebig appears to suppose that the poisonous action of hydrocyanic acid and sulphuretted hydrogen is due to their rendering the iron of the red corpuscles of the blood incapable of absorbing oxygen from the air, and becoming thus the medium of its transfer to the blood and tissues: but to this hypothesis it may be objected that the blood of an animal poisoned with hydrocyanic acid exhibits the usual changes on exposure to the air. Sulphuretted hydrogen does seem permanently to injure the composition of the blood, but it does not affect the red corpuscles merely; for it renders the blood fluid, as well as of a dirty red colour. It does not seem possible now to deny the fibrin and albumen a share in the absorption of oxygen, as well as the chief place in furnishing the material on which that oxygen afterwards acts.*

* The opinion thus expressed in the former edition corresponds with the views of Mulder, Scherer, and others, subsequently published; but these chemists seem to me to go to the opposite extreme in assigning to the protein the chief share in the process of absorbing oxygen. Many facts (§ 183, 188,) combine to prove that the red corpuscles are pre-eminent in their power to absorb and convey oxygen, although it is by no means certain by what chemical property they do so.

240. *Remedial measures.* — Besides the obvious measure of endeavouring to restore the respiratory function where it is defective, the view taken above of the mode in which the defect is hurtful (§ 236) suggests means by which its injurious effect may be diminished. Whatever lowers the activity of the vital functions will often give relief. Complete rest of body and mind; warmth to the surface and extremities, whilst air is supplied cool and fresh to the face and air-passages; and the employment of various sedatives, which reduce the circulation and other vital functions to a lower standard, (or, in the language of Laennec, diminish the want of breath,) such as digitalis, conium, hyoscyamus, &c., should all be adopted. Other medicines, such as æther, belladonna, stramonium, lobelia, &c., sometimes relieve dyspnœa, but they probably act in another way by removing spasm or other mechanical impediments to respiration.

241. In extreme cases bordering on asphyxia, the enfeebled circulation may require stimulants (§ 235), and the engorgement of the venous system may call for depletion at the same time; in different instances one or the other of these conditions may most need attention; sometimes both must be attended to in the same case. It appears from the researches of Chossat, Erichsen, and others, that no stimulant is so generally useful as that of heat to the whole body; and in the experience of the officers of the Royal Humane Society, the warm bath has been found the most useful remedy in restoring animation suspended by submersion. Warm frictions and stimulating applications are likewise very serviceable in exciting the failing circulation.

242. Experience has not yet furnished us with any other means of arterializing the blood than the process of respiration. This process may in some cases be carried on artificially, either by mechanical means, such as the inflation of the lungs, or by electricity applied to the muscles of respiration, (the diaphragm and abdominal muscles alternately;) or it may be helped by bronchotomy; or by chemical means, such as the supply of pure oxygen or nitrous oxide. Whether the internal administration, or the injection into the veins, of saline and other matters containing much oxygen in loose combination, such as the chlorates, nitrates, and some peroxides, may not be made to aid in some degree in compensating for defective respiration, is worthy of consideration and more extensive trial than it has yet received. If these matters could furnish oxygen to the blood, they would yet leave unaccom-

plished the other office of respiration, the removal of carbonic acid. Might this be accomplished by the administration of free alkalies? In some cases of asphyxia by carbonic acid gas, I have thought that some benefit in the progress towards recovery was derived from the use of liquor potassæ combined with chlorate of potash. Possibly warm baths containing these ingredients might be made serviceable, as well as friction of the surface of the body with these solutions and those of similar matters.

243. The congested state of most organs, which occurs when the respiratory process is imperfect, necessitates the employment of remedies suited to the removal of this condition; it is from a disregard of this consequence of imperfect breathing that many fall victims to the secondary effects of apnœa. The lungs, the brain, and the liver suffer from it most. The best remedies in these cases are mercurial and other medicines which act freely on the secretions (§ 173). Probably these act in part by making the liver assist the lungs in their office of decarbonizing the blood. The speedy relief afforded to dyspnœa by a bilious diarrhœa has several times seemed to me to countenance this notion.

244. When the respiratory changes of the blood are reduced by disease within a narrower sphere, it becomes an object not to increase the hydrocarbon of the blood by the use of food with much fat or by the employment of spirituous liquors; lean meat and other fibrinous articles, with farinacea and fruit abounding in vegetable acids, should form the chief sustenance.

SECTION XIV.

CHANGES IN THE BLOOD BY SECRETION.

245. Having already noticed this subject under the head of *diseased secretion* (§ 158), it will be unnecessary to dwell long on it here; but it will be useful to glance at the changes which result from the retention in the blood of matter which ought to be excreted, and which gives rise to various important disorders.

The most remarkable instance of disorder arising in this manner is exhibited in *defective secretion of urine* (§ 70, 170). The extreme power of this as a cause of disease was shown in experiments first performed by Prevost and Dumas, in which the

kidneys of animals were extirpated. On the third day after the operation, there came on vomiting, diarrhœa of a copious brown liquid;* fever, with heat sometimes as high as 110°, and at other times as low as 92°; pulse very small and frequent; breathing laboured: death ensued from the fifth to the ninth day. After death there were found effusion of serum in the brain, copious mucus in the bronchi, and bilious fluid and fæces in the intestines. The liver appeared inflamed (?) and the urinary bladder much contracted. The blood was more watery than is natural (§ 222), and was found to contain urea to a large amount: thus five ounces of blood of a dog yield twenty grains of urea; and two ounces of cat's blood, ten grains.

246. The symptoms induced in defective secretion of urine resulting from degenerative disease of the kidneys are very similar to those just mentioned, but more diversified, partly from the defect taking place in different degrees as to amount and time. Thus, in acute cases of albuminuria, or acute aggravations of old ones, there may be epileptic convulsions, low delirium, and other typhoid symptoms passing into coma (§ 129), suffocative catarrh, obstinate vomiting, diarrhœa, or inflammatory effusions in the serous cavities, any of which may end in death. In slower cases, cachexia and dropsy may ensue more gradually, as the blood and solid structures become altered. All these effects may be traced to excrementitious matters being retained in the blood, and especially urea, which has in very many instances been detected in considerable quantities: when in the greatest amount, acting on the nervous system as a narcotic poison (§ 129); when in smaller, operating as an irritant, and inducing low inflammations in various membranes and viscera; and in still lower degree causing sundry functional disorders, fluxes, and dropsies, impoverishing the blood, and inducing degeneration of certain textures (§ 212). It has been before mentioned (§ 170) that Professor Frerichs ascribes the worst effects of urea in the blood (coma, convulsions, &c.) to its being converted into carbonate of ammonia by a further fermentative process; and this notion is rendered more probable by the fact that urea is sometimes present to a considerable amount in the blood without any serious symptoms. But the tendency to

* From the researches of Bernard and Barreswil it appears that the matter excreted from the intestines contains a quantity of ammoniacal salt which results from the elimination of urea from their surface.—*Dr. Day's Lectures on Animal Chemistry, Med. Gaz., Sept.*, 1847.

local inflammations and effusions, and gradual degeneration of the blood and textures probably depend on the imperfect elimination of urinous matter from the circulating fluid.* It has been already mentioned that the blood in albuminuria loses its proper amount of red corpuscles (§ 185) and albumen (§ 222), and the diminution of these assists in accounting for the weakness, dropsy, and degenerations which commonly ensue in protracted cases. The several results now enumerated may be differently presented in different cases, and the treatment should be varied accordingly.

247. The effects of a *defective secretion of bile* have not been so accurately determined. The presence of bile in the blood is often obvious in the yellow colour of the serum and fibrin, which changes to the characteristic green on the addition of nitric acid; in such cases, analysis has discovered, besides the bilin and the biliphæin, an increase of fatty matter to double or treble the ordinary proportion. In several cases of fatal jaundice connected with structural disease of the liver, I have observed extensive ecchymoses on the legs, which were probably due to the destructive influence exerted by bile on the red corpuscles (§ 187); and I have already stated (§ 171), that in most of the cases of purpura which I have seen, there has been imperfect action of the liver, the most effectual treatment being accordingly by the use of medicines which this circumstance suggested. The presence of bile in the blood, although sometimes causing tingling, pruritus, and cutaneous eruptions, does not appear to produce so much local irritation and inflammation, or change of the blood constituents and general dropsy, as that of urea does. Bile seems to be effete and noxious matter rendered comparatively harmless that it may be again absorbed into the blood and employed as a fuel in support of the animal temperature, before it is finally expelled from the system. Still it appears from very prolonged cases of diseases of the liver with or without jaundice, in which the dropsy is not local merely (ascites), but general (anasarca and hydrothorax), that the blood at last is impoverished, and that the whole body becomes cachectic. Andral found that in dropsical sheep, with flukes in the liver, the albumen, as well as the red corpuscles of blood, was diminished. Symptoms of giddiness, faintness, drowsiness, and nausea often occur

* The diminution of the salts in the urine, particularly the chlorides, noticed by several observers to occur in various inflammatory diseases, is probably connected with a corresponding increase in the diseased parts.

in connexion with imperfect action of the liver, together constituting what is commonly designated by the term *bilious attack*, and these are relieved by medicines which promote a free flow of bile; but whether all this is caused by retention of the excrementitious matter in the blood, or by the sympathy (§ 152) of the brain and heart with the stomach and liver, is uncertain; but in severe cases the symptoms are sometimes alarming from the depression of the heart's action, feeling of death-like oppression, and overwhelming vertigo; a very acid fluid is often vomited, and subsequently bile in quantities; and not unfrequently a very dark coloured bile passes downward with great relief to all the symptoms.

248. The remedial means to be directed against an accumulation of the urinous constituents in the blood comprise chiefly medicines which increase the secretions (eliminants), and those which counteract the pernicious influence of the excrementitious matter on the various functions, including that of nutrition. Of eliminant remedies, doubtless, diuretics, which may restore the function of the failing secretory organ, are most called for; but it often happens that the kidneys are diseased, and will not answer to their usual stimuli, as it occurs in inflammation, extensive congestion, and degeneration of these glands. Under these circumstances purgatives, especially those that excite a copious watery discharge, and diaphoretics, may give relief, by effecting the purification of the blood by other emunctories; and in case of coma, convulsions, or extensive dropsy from uræmia, these remedies, if freely and promptly used, often succeed in averting a fatal result. In this way a dose or two of calomel, followed by repeated saline purgatives, may give seasonable relief. Saline purgatives and diuretics are generally safer and more efficacious than others; but croton oil, jalap, gamboge, and elaterium are sometimes required where great promptitude and energy of action are wanted. In more chronic cases, saline purgatives and diuretics are commonly more useful than others, as they seem more surely to act as eliminants where the blood is diseased: but they may be advantageously combined with other remedies, such as the preparations of dandelion, broom, foxglove, &c. To promote diaphoresis, external warmth, applied by the vapour bath or hot-air bath, is more effectual than internal medicines; but sudorifics, according to my experience, are much inferior in utility, as eliminants, to purgatives and diuretics.

249. As the effects of uræmia are various in different cases, and even in different parts and functions, the means to counteract them must be varied so far as they have any efficiency. It is uncertain that we have any means of counteracting the narcotic influence of uræmia; but if this depends, according to the notion of Frerichs, on a fermentative conversion into carbonate of ammonia, some good might be expected from antiseptics and perhaps from the mineral acids. In a conversation with Dr. Simpson on this subject, he suggested that part of the beneficial influence of chloroform in cases of infantile and puerperal convulsions (which are generally connected with uræmia) might be due to the chlorine preventing the injurious development of carbonate of ammonia in the blood. In more chronic cases of uræmia, I think I have seen good results from the free use of chlorate of potass and nitric acid, whilst the depression of the muscular power (including the respiration), is combated by diffusible stimulants. But the local action of the urinary constituents in the blood is irritant; hence arise irritation and inflammation of serous and mucous membranes, requiring local antiphlogistic remedies, the most efficient of which are blisters. The tendency of excrementitious matter to impoverish the blood and to promote degeneration of tissues is to be opposed by nourishing diet and by tonics, especially those containing iron; but these are rarely borne well, unless in very small doses, and they may be advantageously combined with iodine, bromine, and salines, as in certain mineral waters, which act as eliminants as well as tonics.

250. The indications of treatment in cholæmia are similar to those in uræmia, with this difference, that cholagogue purgatives take the precedence of other eliminant remedies. The most potent of these are the preparations of mercury; but their weakening operation forms an objection to their being used too largely or too long. They may be combined and followed by saline aperients and diuretics, especially the sulphates of soda, potass, and magnesia, the hydrochlorate and phosphate of ammonia, together with suitable additions of senna, aloes, and taraxacum, all of which have a distinct influence on the biliary secretion. The nitro-muriatic acid has been reputed to promote the biliary secretion, especially when used in a bath or as a lotion over a large surface of the body. Nux vomica, in the form of extract, and its active principle, strychnia, have also been supposed to exercise some influence

on the secretion of the liver, whilst they certainly possess valuable properties as a tonic to the alimentary canal.*

What are called bilious attacks are usually connected rather with an excessive than a defective secretion of bile; but probably the chief symptoms depend on its imperfect elimination from the liver and its ducts, as well as its presence, sometimes in a decomposed state, in the stomach and intestines. An emetic and diluents will give the speediest relief where vomiting is unavoidable, but it should be followed in due time by a mercurial purgative; and where the sickness is less urgent, the latter, with effervescing salines, is generally sufficient. For the prevention of these attacks, it is important to avoid all fat and highly-sweetened articles of diet; to be very moderate in the use of fermented liquors; to use regular exercise, especially on horseback; and carefully to attend to the action of the bowels.

251. The *perspiratory secretion* contains lactic acid and lactates of soda and ammonia, which probably proceed from the transformation or decay of the textures, particularly the muscular, which the researches of Liebig have shown to contain a large preponderance of this acid (Chemistry of Food, &c., 1847). Hence these products abound during great muscular exertion; and when perspiration is checked by external cold (§ 77), they are accumulated in the blood, thus often causing rheumatism, urinary disorders, or cutaneous diseases. The very serious effects that sometimes result when cold is suddenly applied to the perspiring body may be partly referred to the same cause, as well as to the disorder produced in the circulation.† Rheumatism is especially liable to occur as an effect of cold and wet, when the body is

* In cases of prolonged jaundice, after mercury has been used as long as is prudent, and the fæces are still without bile whilst the urine is deeply tinged and loaded with lithates, the most generally useful combination of remedies that I have tried has been that of an effervescing draught comprising the three alkaline carbonates, with strychnia in doses of $\frac{1}{40}$th to $\frac{1}{20}$th of a grain, dissolved in the citric acid used for the saline, whilst the surface of the body is sponged twice daily with a nitro-muriatic acid lotion. The extract of nux vomica, in doses of $\frac{1}{6}$ to $\frac{1}{3}$ of a grain, twice or thrice daily, is a useful addition to a pill of rhubarb, aloes, or taraxacum, in cases of torpidity of the liver and bowels, when it is desirable to avoid the frequent use of mercury.

† Dr. R. Willis has suggested that checked perspiration may prove hurtful by rendering the skin dry, and therefore unfavourable for vital changes supposed to take place in the cutaneous capillaries. But if this were the only or chief cause of mischief, it might be always removed by the warm bath, or any other means of moistening the surface; so also pernicious effects should *always* result from a dry state of the skin. In neither case is this consistent with facts.

fatigued by much muscular exertion (§ 30); and I have sometimes observed that the rheumatism chiefly affects the limbs which have been most exercised. When the skin fails to excrete, increased work is thrown on the kidneys, and hence may result various diseases of these organs: if these organs fail in the performance of their task, the lactic acid accumulates in the blood, and, probably acting as a ferment (§ 56), causes the formation of more, and of kindred products: these, in inflammatory subjects, excite rheumatic fever; that is, fever, with inflammation of more or fewer of the joints, and often of the membranes of the heart. In cachectic persons the same acid matters cause miliary fever, erysipelas, or pemphigus; and in more torpid frames, various local rheumatic or gouty affections. All these cases are frequently remarkable for the acid character of the cutaneous and renal excretions,* and in a few instances the blood has been said to possess acid qualities, or to be deficient in its usual alkaline reaction. (Dr. Day's Vogel, p. 80.) I have never detected any approach to an acid reaction in the serum of the blood in any disease, but repeatedly I have found the effusions in serous membranes decidedly acid. In one case of peritonitis, in which the peritoneal fluid caused smarting of the hands of the operator, it was found to redden litmus paper most strongly. Dr. Garrod, in rheumatic cases, always found the blood alkaline.† He could not discover any lithic acid in the blood of patients with rheumatism, whilst it was always present in that of the subjects of gout. In low forms of rheumatism, especially the neuralgic, the materies morbi is probably oxalic acid, as was originally suggested by Dr. Prout; for I have in numerous instances found an abundance of the octohedral crystals of oxalate of lime in the urine, especially when the patients began to convalesce. The only instance in which oxalic acid has ever been detected in the blood was that of a patient suffering from chronic gout, who was for some time under my care at University College Hospital. In this case Dr. Garrod detected a very appreciable amount of crystals of oxalate of lime in the blood. The man died dropsical with albuminous urine; the uriniferous tubes were found obstructed with lithate of soda. (Med.-Chir. Trans., 1850.)

* In patients with acute rheumatism, I have frequently found the perspiration of the affected joints more strongly acid than on other parts. The vesicles of miliary eruption contain a fluid which also strongly reddens litmus paper.

† Med.-Chir. Trans., 1854.

252. The treatment in rheumatism, and other diseases arising from defective excretion, therefore, should not be merely antiphlogistic, but also of a kind calculated to eliminate the morbid matter from the blood. In slight cases, topical heat, stimulant frictions, and sudorifics may suffice for the cure; but in most instances, the kidneys and liver should be excited to assist in the process of elimination; and various combinations of colchicum and alkaline carbonates and other salines, with mercury, opium, and iodide of potassium, generally effect this purpose very satisfactorily, and speedily and permanently remove the disease. Where the disease is more decidedly asthenic, and the urine exhibits a deposition of oxalate of lime with, or instead of, lithates, or acid phosphates, great advantage may be often derived from the employment of measures calculated to raise the tone and vital energies of the circulating and secreting organs, such as the administration of bark, quinine, arsenic, and iron; and these remedies are the more eligible in cases of neuralgic rheumatism, because the attacks are then periodic, with intervals of depression that are highly favourable to the influence of the medicines.

Within the last few years two new remedies for rheumatism have been much extolled, as effecting a cure more surely and rapidly than any mode of treatment previously in use. One is nitrate of potass in large doses (from ℥ss to ℥iij per diem) much diluted with barley-water, ptisan, or other diluent. This treatment was strongly recommended by several English physicians of the last century, and has recently been introduced in France by M. Martin Solon, and here by Dr. Basham. The other is lemon-juice, also given in large quantities, as first advised by Dr. Owen Rees. There is good testimony in favour of each of these remedies, and the trials which I have made of them have convinced me of their utility; but for certainty and speed in curing rheumatism, they do not appear to me to equal the combination of colchicum with alkalies, which I have been in the constant habit of using during the last twenty years. Both nitre and lemon-juice have more action on the kidneys than on any other secretion, and this is the effectual mode in which colchicum with alkalies operates; but it is not improbable that the former remedies may have a more direct alterative action on the composition of the blood, promoting the destruction of the acid morbific matter by combustion or some process of decomposition. The acid of lemon-

juice is itself certainly decomposed in the system; and it may in its own destruction involve that of the kindred lactic or other acid which causes the rheumatism. In this way the alkaline lactates are certainly decomposed in the healthy body, the lactic acid being converted into carbonic acid and water in the course of the circulation.*

Neither the lemon-juice nor the nitre treatment has so depressing an effect as that with colchicum, and therefore they may be more eligible for cases unattended with much inflammatory excitement; but, it may be added, that they are inferior to colchicum in the severer forms of the disease, where many joints are affected, and especially those complicated with inflammation of the membranes of the heart; in which case, also, blood-letting, mercurials, and other antiphlogistic remedies are required in addition. My own experience would lead me to assign to colchicum with carbonated alkalies the highest place in the list of remedies for rheumatism, this being the one most efficacious in subduing the specific or rheumatic element of the disease; but it is insufficient where inflammatory excitement runs very high, or involves the heart in inflammations which are not merely rheumatic in nature: under these circumstances, blood-letting, local and general, calomel and opium, and, at a later period, blisters, are required in addition to the colchicum and alkali. Opium or morphia also affords most valuable aid in the treatment in cases of extreme pain or nervous excitement; and also where the bowels are irritable and are disposed to diarrhœa under the influence of the colchicum. The proper curative action of the latter medicine is through the kidneys; and its beneficial operation is generally accompanied by an increase in the solid constituents of the urine, as indicated by its quantity and specific gravity. The diarrhœa produced by colchicum and other purgatives often reduces rheumatic swellings for a time; but the improvement is not lasting, and there is usually a relapse of the disease so soon as the purging ceases. The eliminating process which colchicum establishes through the kidneys should be kept up for some time after pain and other local symptoms have been relieved; but this may usually be effected by reduced doses, and its weakening operation may sometimes be

* Dr. Bence Jones has found that the large exhibition of lemon-juice causes the appearance of lithic acid crystals in the urine; and he justly remarks that this might lead to the formation of red sand or calculus (Med. Times and Gazette, Oct. 1854). This result may be prevented by adding a little carbonated alkali to the lemon-juice, an expedient which I have generally adopted.

counteracted by combinations with bitters or mild tonics. In cases where the stomach and bowels do not tolerate the colchicum, a substitute may be found in iodide of potassium, but it is by no means of equal efficacy.

Both the disease itself, and the chief remedies used to subdue acute rheumatism, cause an expenditure of the blood and tissue material, and therefore a tonic and nutrient treatment is required to re-establish the health; and for this purpose, quinine, iron, the mineral acids, and cod-liver oil, deserve especial mention as the most suitable aids to nourishing diet.*

It is well to bear in mind that independently of the action of medicines, Nature has her own methods of purifying the blood from the materials of rheumatic and kindred diseases; and these methods are the more adequate and efficient in proportion to the vigour of the constitutional powers and the moderate amount of the disease. Thus not only by throwing off the acid matter by the kidneys, bowels, and skin, but also by its decomposition by the action of the oxygen absorbed in respiration, may the blood rid itself of the morbid material; and it is by promoting all these processes that active or athletic exercises gradually increased, combined with baths or other water cure, have been sometimes found a very efficient remedy for chronic rheumatic affections.†

* The treatment for acute and sub-acute rheumatism generally adopted during my charge at the hospital of University College was as follows:—after one mercurial purge, colchicum wine was given to all, in doses varying from twenty to sixty minims with the same number of grains of carbonate of soda or potash in peppermint water, every four, six, or eight hours, according to the severity of the symptoms. In case of disposition to diarrhœa, a few drops of laudanum were added. In very acute cases with high fever, and many joints implicated, one venesection to twelve or sixteen ounces was sometimes practised; and in case of complication with cardiac inflammation, blood was drawn from the region of the heart by cupping or leeches, generally followed by blisters. Under the same circumstances, calomel and opium or morphia, with ipecacuanha, was generally given once or twice daily until the severe symptoms were relieved.

The general result of this treatment was that on an average of 300 cases, convalescence (that is, freedom from fixed pain, tenderness, and swelling) was established in five days: but to secure the patient against relapse, the remedies were continued for from one to three weeks after; during the latter half of which period the colchicum was combined with or replaced by a tonic, and the patients allowed full diet. That the colchicum was the most efficient *anti-rheumatic* remedy employed in this treatment was proved by the much more tedious progress of a few cases in which, on account of irritability of stomach or bowels, the colchicum was omitted, and the alkalies and mercurials alone continued.

† It appears from the experiments of Dr. S. Lehmann and others (Brit. and For. Med. Chir. Rev. July, 1855), that the cold sitz-bath distinctly increases the quantity of urea in the urine, probably by augmenting the activity of the respiration, which is rendered more frequent, although the pulse is slower.

SECTION XV.

CHANGES OF THE BLOOD FROM THE TRANSFORMATION OF CHYLE AND OF THE TEXTURES OF THE BODY.

253. The changes of the blood resulting from the transformation of chyle and of the textures, involving the processes of nutrition, reparation, and decay, have been too little examined to supply the pathologist with a complete view of the subject. It seems quite warrantable, however, to connect with these changes some remarkable states of disease, on the pathology of which chemistry has thrown much light, *gout*, for instance, and other *lithic acid diseases* (§ 176), *diabetes*, both *saccharine* and *ureal*, and *obesity*.

254. Gout, and the commonest kind of urinary gravel, are now generally considered to depend on the production in the system of an excess of lithic acid.* This acid, being a highly azotized compound, is abundantly generated in those who take a large proportion of animal food, and in whom the digestive and assimilative processes are impaired; the more these processes are weakened, and the less digestible and assimilable the food supplied, the more surely will be found this acid, with ammonia, the product of degenerating decomposition. Hence the disease is engendered not only as a consequence of general full living and sedentary habits, but especially from the use of highly-seasoned and over-cooked meats, cheese, pastry, and strong acid wines: the avoidance of such articles is a more effectual safeguard against gout, than more general abstinence, which in many cases would be absolutely hurtful. Lithic acid, like urea, is one of the lower forms into which the higher animal principles, fibrin, albumen, and gelatin,

* This view, although generally admitted on inferential evidence, was for the first time proved in the case of a gouty patient of mine at the University College Hospital, in whose blood Dr. Garrod readily detected the presence of lithic acid. The case was one of chronic gout, and strikingly illustrated the pathology of the disease by presenting a total absence of lithic acid in the urine, until colchicum had been exhibited for some time, when its characteristic crystals appeared under the microscope. Dr. Garrod has since succeeded in detecting lithic acid in the blood of a large number of persons affected with gout in different forms. It is remarkable that before and during a fit of gout, the lithic acid disappears from the urine; and Dr. Garrod could not detect it in the blood taken from a joint affected with gouty inflammation. It would seem as if the inflammatory process in some way decomposed the lithic acid.

tend to pass in their progress towards resolution. Hence it is produced in excess where there is more azotized matter than is wanted for the reparation of the textures, or than the vital assimilating powers can appropriate for such a purpose. It results also from the decay of the textures after much exertion, and especially during febrile or inflammatory irritation, when copious deposits of the lithates appear in the urine.

The morbid effects of an excess of lithic acid vary considerably, according to the amount of the excess and to other circumstances. The kidneys are the proper emunctories by which it is eliminated from the blood, and these sometimes suffer from the irritation which it causes; hence nephralgia and nephritis* may occur; or the water and alkali secreted with it in the urine may be insufficient to hold it in solution, and it may be deposited in the form of crystallised sand or gravel, or calculus, in the kidneys or bladder; various irritations and obstructions in the urinary apparatus are thus induced.

But sometimes the kidneys may fail in their power of elimination (§ 170); in fact, before a fit of gout, the lithic acid does disappear from the urine; it then, with its compounds, accumulates in the blood, and may cause various forms of irritation and functional derangement (irregular gout, which is extremely common, and of infinitely varied kind and seat:) until at length some circumstance may fix the mischief in a limb, when a fit of regular gout is the result. In this fit, if perfect, inflammation is excited, and more or less of febrile disturbance, which ends with a copious deposit in the urine, effecting the removal of the morbid matter (§ 165). The more acute and fixed the inflammation, and the smarter the fever, the more abundant is the deposit after it, and the more free is the patient from subsequent disease. On the other hand, when the inflammation is low, changing its place, and with little fever, it generally tarries long, and the system is not relieved. It is when gout thus lasts long, or frequently recurs, that its material so accumulates in the joints as to be deposited in the form of a plastery or calculous matter, consisting of lithate of

* I have in several instances found in the cortical and tubular structure of the kidney, clustered crystals of lithic acid, which, under the microscope, exhibited such sharp angles and dagger-shaped projections as would afford an easy explanation of the pain, inflammation, and hæmorrhage often attendant on an attack of renal gravel, even when none is obvious in the urine.

soda (chalk stones of gout).* This chronic form of the disorder is connected with a more or less permanent derangement of the digestive or assimilative functions, and this renders the treatment more difficult, or less successful, than is that of the more acute forms. In such chronic cases, lithic acid seems to be engendered in great abundance, and although it is thrown off in large quantities in the urine for an indefinite period, yet it never leaves the body free. Such cases are commonly either hereditary, or they have been rendered inveterate by intemperate habits, or neglect of proper treatment.

255. In saccharine diabetes, the morbid matter is of a nature that is quite contrasted with that of gout and gravel, being grape sugar, a wholly unazotized principle; yet this is also probably produced by derangement in the processes of digestion and assimilation—the condition of the urine being only a consequence of such disorder. The analyses of Ambrosiani, Maitland, and others, have proved the abundant existence of sugar in the blood of diabetic patients, the specific gravity of whose serum occasionally rises to 1060 from its presence: Macgregor has also established the fact of its unusual production during the process of digestion. The facility with which starch and gum can be converted into sugar in the laboratory, especially under the action of acids, throws light on the possible origin of sugar in diabetes; and the actual presence of a very large amount of acid in the stomach in diabetic patients tends to support this mode of explanation. The appearance of sugar in the urine can scarcely be considered otherwise than as a result of its presence in the blood. But sugar is probably formed not only from isomeric principles in the food, such as starch and gum, but in confirmed cases of diabetes may be also derived from a decay of the textures, especially the gelatinous, through a modification of the process by which urea is naturally evolved; for it has been found practicable to convert gelatin partially into glucocol, which has saccharine properties, and probably consists of sugar and urea. Further, it now appears, from the researches of Bernard, that the liver has

* A case of chronic gout that was under my care in June, 1847, afforded me an opportunity of verifying this observation: the matter obtained by puncturing the white tumours of the patient's fingers was of the consistence of thick cream, and consisted of very fine acicular crystals of lithate of soda, with a trace of lime. Dr. Garrod has found little deposits of this kind frequently in the lobe of the ear, and more rarely in the lower eyelid. Their most usual seat is in the small joints of the hands and feet.

the power of forming sugar out of azotized matter; and that sugar thus formed is continually passing through the portal and hepatic veins into the vena cava to the right side of the heart; but it usually disappears in the passage of the blood through the lungs. But in case of the respiratory function being impaired, as from injury to the floor of the fourth ventricle or to the medulla oblongata, the sugar then is not consumed in the lungs, but passes into the general circulation and appears in the urine. It is possible then that the sugar of diabetes may arise either from an excess formed by the digestive organs and liver, or by an interruption to the process by which the sugar so formed is usually consumed in the lungs. Even in healthy subjects, an excessive amount of sugar in the food may sometimes cause its presence in the blood and in the urine shortly after a meal; and in aged persons, and in those whose respiration is habitually impaired, as with pulmonary emphysema, the presence of sugar in the urine is by no means uncommon. The atrophy and cachexia accompanying diabetes probably result from the draining away of the nourishment of the body *with* the excess of sugar, rather than the conversion of all this nourishment *into* sugar. It is now well ascertained that the ordinary animal constituents of the urine are not only present, but are often increased considerably beyond their natural amount.

256. There is a parallel between the indications of *treatment* in gout and in diabetes, although in the fulfilment of these indications the means to be employed are most opposite. In both cases, we must withhold those articles of diet from which the morbific matter can be most readily generated. Thus it is important to withhold animal food and stimulating condiments and beverages in cases of gout, and to use these very articles, excluding all saccharine or amylaceous substances, in cases of diabetes. In both disorders it is advisable that those processes of digestion and assimilation, from a perversion of which the morbid matter is probably generated, should be invigorated. But, unfortunately, we know too little of the processes, and of the circumstances which influence them, to be able to fulfil the indication with any certainty. A gouty constitution, in the absence of the febrile paroxysms, is often much improved by the use of bitters and other mild tonics; and in diabetes, amendment occasionally takes place during the exhibition of opium and some of the stronger

astringents and tonics, such as preparations of iron and copper. As in both gout and diabetes the mal-assimilation seems to be connected with an unusual development of acidity in the system, alkalies have been found to be alike useful; for reasons, however, presently to be mentioned, soda and potass are more suited to gout, whilst ammonia and magnesia, or the alkaline phosphate of soda, succeed best in diabetes. To ensure their full effect, alkalies must be given largely in the form of carbonates.

In the effect which each exerts on the economy, there is a great difference between the morbid matter of gout and that of diabetes. The sugar of the latter has no tendency to accumulate in the system and produce local derangements; but, acting as a powerful diuretic, it passes rapidly away, carrying with it a great quantity of water and of the other constituents of ordinary urine (§ 165); the thirst, dry skin, and emaciation of diabetes, seem to be chiefly due to this cause. The common complication of diabetes with pulmonary consumption shows also that the plastic process of assimilation is therein degraded (§ 211). Diabetes often terminates in death by coma, from failure of the power of the kidneys to secrete urine (§ 249), anasarca usually preceding the fatal event.*

* Diabetes is one of those diseases which we may fairly hope to cure when our knowledge of animal chemistry shall be more advanced. The fact that febrile and inflammatory diseases suspend it for a time, that is, cause the sugar to disappear from the urine, is a proof that the morbid production of sugar is not necessarily permanent, and we may therefore anticipate that it may be prevented by artificial means. Experience has not, however, as yet discovered any agent capable of effecting this in the greater number of cases. Opium, alkalies, permanganate of potass, and rennet, have severally been said to be successful in a few instances, but they have proved of no avail in general experience. Carbonate of ammonia (gr. x. *ter die*) has seemed to me the most useful medicine for counteracting the prevailing acidity, which it does without increasing diuresis or general depression. Cod-liver oil is of real service in sustaining the nourishment of the body and removing the craving appetite which is commonly present.

The diet is of primary importance in the treatment of diabetes, as the strict exclusion of all saccharine and amylaceous articles constitutes the only sure means of controlling the disease. This must be done most rigidly in all decided cases; otherwise little advantage will result from restriction. Dr. Prout permitted patients to eat brown bread and to drink porter; but in my experience a very small quantity of either of these articles has wonderfully increased the saccharine quality of the urine: neither have I found gluten bread answer; it is difficult to make well, and it is not relished by patients. The best substitute for bread is a biscuit made of fine bran with egg and a little lard. The bran must be well washed to remove the flour from it; then dried, and ground fine in a steel mill (made for the purpose by Mr. White, Holborn); and then mixed with the other ingredients and baked into a kind of cake, which is by no means unpalatable, and is very much prized by patients who are deprived of bread. Watercress, greens, and cabbage may also be

The lithic acid of gout and gravel, unlike the sugar of diabetes, has a tendency to accumulate in the body, and to cause the local and general irritations already mentioned (§ 254). Hence it becomes of great importance to counteract its irritating properties, and to promote its elimination from the system. The medicines which are most efficacious in doing this are alkalies, or their carbonates, or their vegetable salts, combined with colchicum, or iodide of potassium, saline mineral waters, and alterative aperients. These all increase the action of the kidneys and intestinal canal, and drain off the offending matter from the system; but the operation of colchicum is far more certain than that of the others; and its permanent efficacy depends especially on its continued action on the kidneys more than on any other excreting organ. The impropriety of using active antiphlogistic treatment in gout has long been acknowledged; and it is a general opinion that a regular fit of the disease tends to relieve the system from the morbific matter, and therefore ought not to be checked or too rapidly cured. Two facts, first ascertained by Dr. Garrod, and confirmed by others, are worthy of note in connexion with this subject. One is the disappearance of lithic acid from the urine just before and during an attack of gout, and its reappearance on its decline; the other fact is the presence of lithic acid in the blood of gouty subjects, and its absence in the blood of the inflamed part. It appears probable, therefore, that the gouty inflammation, when acute and sthenic, tends to get rid of the lithic acid both by its decomposition in the vessels of the inflamed part, and by its elimination through the critical discharges which it promotes at its

allowed, with meat; and a little cream instead of milk with tea or coffee. Sound claret, or weak pale brandy-and-water may be used as a stimulating beverage.

Although it is doubtful how far a cure can be effected by strict exclusion of saccharine and starchy food, yet it is quite certain that the disease is suspended by it, and patients regain flesh and strength, and may enjoy life for many years. I know several persons who were found to be diabetic from five to fifteen years ago, and who are now in the enjoyment of very tolerable health, although the urine still contains sugar.

It is very difficult to estimate the efficacy of medicines supposed to have a direct influence in restraining the production of sugar in the system, because the examples in their favour are so few. Instances have occurred within my own knowledge in which the urine lost all trace of sugar when the patients were taking severally, ammoniaret of copper, hydrosulphate of ammonia, tincture of sesquichloride of iron, and liquor arsenicalis. Further experience alone can determine whether in any case these medicines were really instrumental in producing the change. The permanganate of potass (chamæleon mineral) was recommended as a remedy for diabetes on account of its remarkable oxidising property by which it rapidly decomposes sugar and other hydrocarbonaceous elements.

decline. Instead, therefore, of attempting to subdue gouty inflammation by leeches, cold applications, and reducing measures, it is expedient to promote it by warm coverings of French wadding and oil silk, whilst the pain is allayed by occasional applications of a little spirit, chloroform, or opium, and the critical discharges are encouraged by moderate doses of colchicum with alkalies.*

257. It is supposed by most chemists, that the urea excreted by the kidneys is chiefly derived from the transformation or decay of the azotized textures of the body (§ 254), most of their carbonaceous matter being abstracted by the affinity of the oxygen in the blood, and thrown off from the lungs in the form of carbonic acid gas (§ 232). According to Liebig, whatever excites the activity of the function of respiration, which supplies the consuming oxygen, increases the production of urea; active bodily exercise acts in this way. Under some circumstances, however, the formation and excretion of urea is much augmented, without any obvious

* The treatment of an attack of simple gout is usually an easy affair; in fact, there often is such a spontaneous disposition to cure, that it may be wise to interfere as little as possible with the process of nature. But it is otherwise with the gouty constitution, which causes a tendency to repeated and prolonged attacks, often of an irregular kind, involving the disorder of various functions and derangement of the general health, without any disposition to a spontaneous termination. Now this gouty constitution is also dependent on the production of an excess of lithic acid in the system; and although generally more amenable to the action of eliminant remedies, especially colchicum with alkalies, than to any other treatment, yet the weakness of stomach and other organs, occasionally predominant, may much interfere with the use of these remedies, and may call for others of a different class. Thus where the circulation is very weak, bitters, tonics, and even stimulants may be necessary to enable the excretory organs to throw off the morbid matter; and any weakening influence which the eliminatory medicines may have, may be more or less counteracted by these means. But there is a seat which the gouty disorder sometimes occupies, which entirely interrupts the usual course of treatment, and may render the case unusually grave. This is when it attacks the stomach, causing more or less pain, nausea, and obstinate vomiting. Here colchicum and iodide of potassium are quite out of the question; and except small effervescing draughts with an excess of alkali and a little hydrocyanic acid, and a few grains of simple calomel, medicines of any kind are rarely tolerated. Small bits of ice slowly swallowed, should take the place of drink; and the only nourishment likely to be retained is in spoonfuls of milk and soda-water, chicken tea, or thin arrowroot flavoured with brandy. In some instances the vomiting has been checked by sinapism to the epigastrium, or by minute doses of strychnia (from $\frac{1}{40}$th to $\frac{1}{20}$th of a grain); in others opium or strong stimulants have been successful.

According to my experience, gout in the stomach is the most formidable variety of the disease, and therefore it is the more important to be guarded against. The occurrence of any nausea, or pain in the stomach, should be taken as a warning against the continuance of colchicum or any other medicine of a sickening tendency; and in the intervals between attacks the tone of the stomach should be strengthened by bitters, with a due attention to the diet and regimen.

excitement of the respiratory function. This is the case in the diabetes ureosus described by Dr. Prout, and which he considers a forerunner of saccharine diabetes. Such free production of the matter which seems to be properly a kind of debris of the body, indicates organic debility, or exhaustion of the vital powers, and has been observed to occur in young persons who have grown rapidly, and in those weakened by great mental exertion and want of sleep, or by venereal excesses. An excessive excretion of urea (or of carbonate of ammonia, which is of kindred composition,) sometimes takes place in typhoid fevers, and is attended with great loss of flesh and strength. A great and sudden increase of urea in the urine was ascertained to have taken place, in some patients with acute rheumatism, and in others with delirium tremens, in University College Hospital, at the decline of the fever and other acute symptoms. This perhaps ought to be viewed as arising from the removal of the urea which had accumulated, rather than from an increased formation of it; and this fact may be connected with another ascertained by Professor Chelius and Dr. Lewins, namely, that colchicum causes an augmented discharge of urea and the other organic principles of the urine (§ 252, 173). The operation of diuretics, especially those containing alkaline and saline matter, is also eliminative, promoting the removal from the blood of the products of decay; but it is very probable that both these and saline mineral waters, and even plain water when taken in excess, tend to increase the waste of the blood and of the tissues nourished by it (§ 231).

In cases of excessive formation of urea, all circumstances which depress or exhaust the organic life should be avoided, as for instance great excitement of body or mind; waste should be compensated for by a generous diet, and the nutritive function should be sustained by tonics. Opium and other narcotics are found to be useful in reducing the quantity of urine in the diabetes ureosus; and they probably operate by calming exhausting nervous excitement, and by procuring sleep. The researches of Dr. Böcker show that alcoholic liquors, tea, and coffee, also restrain the waste of the tissues, and thus become the means of giving strength to the frame (§ 56): in this respect they are contrasted with simple water and mere diluents which have a tendency to promote waste, as these augment the solid contents of the excretions.

258. The eduction, or production, of fat from food takes place

with remarkable activity in some persons; and wherever it obstructs or supersedes the proper formation of fibrin and other protein principles more immediately concerned in giving strength to the bodily frame, it amounts to disease. The circumstances in the diet which tend to this result have been already noticed (§ 59, 60), and we have had occasion to mention that sedentary habits and a lowered condition of the respiratory function have sometimes a similar effect (§ 239, 65). But in connexion with our present subject we may remark that there are many reasons for supposing that an excessive production of fat sometimes occurs as an error in assimilation, and may interfere with the sufficient production of other animal principles and with the nourishment of the textures of kindred composition, whilst it not only accumulates in its proper tissue, but invades other textures, lowering their vitality and cohesion, and thus constituting a cause of gradual degeneration. Thus Mr. Gulliver has shown that the atheromatous patches in the coats of arteries, which appear to be a mark of declining age, (natural or premature,) are of the nature of fatty degeneration. The same pathologist has discovered a predominance of fatty matter (chiefly olein, margarin, and cholesterin) in the lungs, the kidneys, and testicles, in various chronic diseases. (Med. Gazette, June, 1843.) A similar abundance of fat has been frequently observed by myself (first in conjunction with Dr. R. Quain, in May, 1845) in the kidneys, liver, and other structures of persons whose habits of excessive intemperance proved fatal, with the production of general cachexia and failure of many functions. This subject will be noticed again under the head of *perverted nutrition*, when the remedies to be opposed to the morbid element, fatty transformation, will be considered.

SECTION XVI.

TOXÆMIA—CHANGES IN THE BLOOD FROM THE PRESENCE OF FOREIGN MATTERS.

259. The blood is probably the chief seat of the morbid poisons which excite various contagious (§ 93), epidemic (§ 88), and endemic diseases (§ 81); and where these act most intensely it is

much changed in its physical characters, being rendered darker, indisposed from defect of fibrin to coagulate, with breaking up of many red corpuscles. Probably, too, the blood is the hotbed in which morbid poisons are propagated, whether by seeds, ova, cell-germs, or parasites (§ 99); and it is through changes in its composition that many of the destructive effects of these poisons are produced (§ 186, 196). We have already noticed some of these changes under former heads of our subject. It will suffice in this place to mention a few examples in which morbid poisons have been traced to the blood.

Dr. Francis Home communicated measles from one person to another by inoculating with the blood of a patient affected with the disease. M. Gendrin describes the following experiment:— A man who had been skinning a diseased animal was seized with a putrid fever, attended with an eruption of sloughing pustules. Some blood taken from this man was injected into the cellular texture of the groin of a cat; the animal was soon affected with vomiting of bile, dyspnœa, frequent small and irregular pulse, dry brown tongue, with slight convulsions, and died seven hours after the injection. The same pathologist produced in animals various severe symptoms, speedily ending in death, by injecting into their veins blood taken from a person labouring under confluent small-pox. MM. Dupuy and Leuret communicated to a healthy horse the malignant pustular disease called "charbon," by injecting into its veins some of the blood of a diseased animal; and M. Renault propagated glanders from one horse to another in a similar way. Andral quotes from Duhamel an extraordinary case, in which blistering, pustules, malignant fever, and death, followed the mere contact of the diseased blood of an animal with the lips. Other instances are on record of sickness, faintness, and serious illness being caused by the odour of blood; and Dr. Copland quotes from Zacutus a marvellous story of three persons being struck dead by the smell of the blood of a patient in the plague.

The mutual influence exerted between various morbid poisons and the blood may be traced in numerous facts in the clinical history of toxæmic diseases; and a few examples may serve as illustrations of the subject in relation to its practical bearings.

It has been already stated that the disposition to suffer from zymotic diseases (Sect. III., Div. II.) is connected with a weakness of the functions generally (§ 23), but that it is more particularly

favoured by the presence in the blood of an easily decomposed azotized matter resulting from the retrograde transformation or decay of tissues (§ 105). Thus after great bodily fatigue; after severe wounds or other injuries; and after delivery of women, where there is more than usual of an effete matter in the blood, there is great susceptibility to zymotic diseases and a liability to them in an aggravated form. So also in the development and progress of these diseases, we have many proofs that their essential seat is in the blood, though their action may be exerted on various tissues or organs. Thus the earliest symptoms are those of general weakness and uneasiness, with disturbance of the circulation more constantly than of any other function; and not unfrequently, as before mentioned, with an obviously altered condition of the blood. In the worst cases of zymotic disease, where the poison is most virulent, the change approaches to putrescence; and the excretions first, and eventually the whole body, exhale offensive odours, and give evidence of the prevalence of a decomposing force opposed to the conservative powers of life; and this corrupting influence may triumph in a few days or even in a few hours before any secondary or local changes can take place. This has been observed to happen in the plague and in the worst forms of putrid or pestilential fevers, in which the blood seems to be so rapidly corrupted that it no longer sustains the functions of life. In like manner the poison of the most venomous serpents appears to exert its deadly influence on the blood, which it renders the medium of death to the whole body.

But the more usual operation of zymotic poisons is of a more mixed character, comprising much local irritation as well as constitutional disturbance and depression. Thus the poisons of the exanthemata produce various specific forms of cutaneous inflammation; and that of scarlatina also affects the throat and frequently the uriniferous tubes, and measles the air-passages,—with inflammatory or congestive disorders. The follicular intestinal lesions in typhoid fever, and the more intense phlogoses and ulcerations of epidemic dysentery, are further examples of local irritation resulting from the presence of a morbid poison in the blood. Now although these local inflammations are proofs of the activity of the respective poisons, and are, in fact, the foci of their multiplication, yet they truly appear to be parts of a process by which the poison is brought to a surface from which it may be

eliminated from the system and the blood freed from its contaminating influence; for they all involve more or less of a process of effusion and discharge, and the more simply and superficially this takes place, without spreading deeply and disorganizing the textures, the more favourable will be the result. Thus scarlatina, the eruption of which is vivid and soon ending in desquamation, the throat-inflammation superficial and attended with free secretion;—measles with full florid eruption, and the catarrhal affection ending early in defluxion and expectoration;—small-pox, with distinct pustules circumscribed by a firm phlegmonous base, which protects the system whilst the pustule maturates, and then soon dries into a hard inert scab; typhoid fever,—in which an early moderate diarrhœa indicates the activity of the intestinal follicles in throwing off the morbid matter;—these are examples of the favourable operation of the *vis medicatrix naturæ* in the removal of a noxious influence. On the other hand, in scarlatina,—where the eruption is not persistent or is livid, and the throat-inflammation is deep-seated, with much swelling, sanious and fœtid discharges, and sloughy patches; in measles,—with a dusky and imperfect rash, and the inflammation of the air passages assuming the form of croup, extensive bronchitis, or even of pneumonia; in small-pox,—a very copious eruption of confluent, flattened pustules, with little or no induration at their base, but much dark red diffuse swelling of the integuments and cellular tissue, sometimes with purple ecchymosed spots or petechiæ, and sanguinolent discharges from various mucous membranes; in typhoid fever,—a torpor of the bowels and other excreting organs, with tympanitis, dark sordes on the teeth and tongue, petechiæ on the skin, and general oppression of all the functions;—in such forms of disease we see evidence of a prevalence of the operation of the poison in depressing the vital powers, in injuring the condition of the blood, and in depressing the local processes intended for the protection of the system. Various combinations and complications of these two opposing influences,—the poison, and the reaction against it,—constitute the infinite diversity in type and form that toxæmic diseases present.

There is good reason to suppose that purulent matter, the germs (§ 90) of carcinoma, and other forms of malignant disease, are spread through the system by the medium of the blood. Pus has been frequently detected in the blood by the aid of the

microscope, first by Mr. Gulliver, and by many subsequent observers. The pus globule is to be distinguished from the pale or lymph corpuscle by its larger size, more marked and often granular cell-wall, by its contained granules or nuclei being more distinct, and sometimes loose in its interior, and lastly by its exhibiting exosmotic and endosmotic properties much more actively. The different effects of pus in the blood will be noticed under the head of results of inflammation. The tendency to symmetrical arrangement which cutaneous eruptions, nodosities of the joints, paralysis from lead, and some other local affections exhibit, has been adduced, by Dr. W. Budd and Mr. Paget, as an instance of effects produced through the medium of the blood—the symmetrical distribution of this fluid on the opposite halves of the body leading to like results in corresponding parts.

260. It is very evident from the phenomena and results of toxæmic diseases, that the blood itself and the organs connected with it possess a certain preservative and correcting power, by the operation of which efforts are made to counteract or throw off any noxious matters which may be present in the circulating fluid The success of these efforts will depend much on the vital vigour of the blood itself and of the organs of circulation and depuration, as opposed to the quantity and virulence of the invading poison. When the latter operates with the greatest energy, as in the bite of the most venomous serpents, or in the most malignant forms of pestilential fever and cholera, the poison seems to overwhelm all resistance, and destroys life in a few hours, apparently by its direct deadly action on the blood and living tissues. The blood after death commonly remains fluid, or imperfectly coagulated, and often it is extravasated in parts, and deeply tinges the tissues in contact with it. Even where the poison is less rapidly and directly destructive, the resisting and eliminating processes, although brought into operation, may be insufficient to prevent a fatal result; and where the struggle is more prolonged, its marks are usually seen not in the blood only, but also in the mucous surfaces, skin, glands, and other organs, which become irritated, congested, inflamed, and even disorganised in the ineffectual processes of resistance and elimination. In this way arise the specific inflammations of the skin in exanthematous fevers, of the throat in scarlatina, of the nose and bronchial membrane in measles, of the follicles of the intestines in typhoid fever, and the irritative discharges of

epidemic cholera, dysentery, and yellow fever. In these several instances, the direct operation of the poison and that of the reaction against it, appear to be equally destructive, and together constitute the features of these respective diseases in their ordinary severer forms. On the other hand, the milder varieties of these maladies show the influence of a moderate operation of the morbid poison, disguised in various degrees by the several processes of irritation or reaction peculiar to each disease.

The preceding view of toxæmic diseases may be extended to comprise the most useful facts ascertained with regard to their treatment. With the most energetic kinds and degrees of poison in the blood, remedies are of little or no avail; chemical antidotes capable of destroying the poison would be equally injurious to the blood which contains it; and if aid is to be derived from any agents, it is chiefly to be looked for from stimulants and antiseptics, or those which excite the vital functions, and those which resist the tendency to decomposition in the animal fluids and solids. And if the influence of the poison is not of the most rapid and overwhelming kind, such means may so far counteract it as to give time for the processes of oxidation and elimination, which are the natural means by which the system is freed from noxious matters.

In the treatment of cases of toxæmia we have, then, to hold in view these indications:—1. To counteract as far as possible their injurious influence, both general and local; 2. To promote their decomposition and expulsion from the system; and 3. To regulate the functions and sustain the nutrition of the body, during the struggle which may last some time between the disease and the bodily powers. A few examples may serve to illustrate the fulfilment of these several indications.

In the treatment of persons under the influence of sedative poisons, such as digitalis, hydrocyanic acid, aconite, &c., which act through the blood, we endeavour to counteract their depressing influence by diffusible stimulants, such as ammonia, alcohol, ether, and artificial heat. In case of poisoning by narcotics, such as opium, alcohol, and deleterious fungi, we endeavour to excite the torpid sensibility and maintain the respiratory movements by cold affusion, sternutatories, sinapisms, mechanical irritation, electric shocks, &c., and by strong coffee and tea, which counteract the soporific tendency. If these means are successful in counter-

vailing the operation of the poison for a certain length of time, the danger is removed; for the poison in that period is so far decomposed or eliminated, that the system is relieved from its effects. In like manner the poisons of typhous and other adynamic fevers have their depressing operation, which is to be counteracted by the judicious administration of wine, ammonia, and other stimulants; but these morbid poisons are more persistent than vegetable sedatives and narcotics, and remaining longer in the blood, require a continued use of not only stimulants, but also of eliminant remedies, which aid the secretions in expelling them from the system. Further, it has been mentioned that these morbid poisons show more or less of a septic tendency, sometimes in their direct action on the blood, and always in their increasing the putrefactive properties of the excrementitious matter, which by their peculiarly offensive odour give evidence of the advance of decay. To limit this process of decomposition, and to deprive its products of their injurious properties, antiseptic remedies become useful; and for this purpose, chlorinated liquids, nitromuriatic acid, chlorate of potass, chloric ether, creasote, and powdered charcoal, have been employed both externally and internally for various toxæmic diseases. Bark and quinine may be considered to possess some title to the same property, but they appear also to have important relations to the vital property of tonicity (§ 124), which give them an antagonistic power against the poison of fevers in general, but more especially of intermittent and remittent fevers. The power of quinine in large doses to cut short the course of continued fever is still a matter of question; and although the experience of a few practitioners testifies in its favour, there is not that concurrence which would be required to establish the efficacy of a great remedy, like that of the same medicine in intermittent diseases. But this last example of remedial action, that, namely, of bark, quinine, and arsenic in intermittent diseases, is also one of antidotal or antagonistic kind, opposed to the operation of a poison or noxious principle in the blood; and in further illustration of this position may be adduced the important fact, accredited by several experienced observers, that small doses of quinine (a grain twice daily) are protective against malarious poisons in persons exposed to their influence.

Another instance of counteractive treatment of blood poison in a more limited degree is in the exhibition of opium and other

narcotics to soothe pain or nervous irritation (§ 149—53) caused by the operation of the poison. In ataxic or nervous forms of fever, in delirium tremens and other toxæmic affections attended with nervous excitement, the operation of narcotics is salutary, not counteracting altogether the morbid poison, but in controlling one of its most mischievous effects, which tends to wear down the vital powers by exhausting excitement. It is very probable that part of the salutary operation of wine and other stimulants, especially chloroform and chloric ether, may be due to their tranquillizing influence on the nervous system, whilst at the same time they sustain the power of the muscular.

But it is by promoting their elimination that nature and remedial art more constantly and successfully operate against noxious matters in the blood. Orfila found that even energetic mineral poisons, such as arsenic, could be given to animals in small repeated doses without any injurious effect so long as a diuretic was exhibited at the same time; and it is well known that the poisonous action of lead, in those whose occupations expose them to it, may be prevented by keeping the bowels constantly free. Fevers and other toxæmic affections are sometimes carried off by a spontaneous diarrhœa, a diuresis, or a copious sweat: and the artificial treatment which most seems to promote a favourable termination of these disorders is that which moderately excites these secretions. Thus mild doses of mercury, antimony, salines comprising all the alkalies combined with citric, acetic, or tartaric acid, and increasing the proportion of ammonia and adding stimulants as the weakness requires,—are the most generally useful medicines in these diseases; and an indication of their successful operation is the free flow of the several secretions, often offensive at first, and giving proof of their containing much decaying animal matter, but gradually becoming more natural as the disease yields. On the other hand, in unfavourable cases the eliminatory process fails, the discharges being either scanty, or so depraved and offensive as to injure the function and structure of the excreting organs, and the body loses all chance of being freed from the deleterious operation of the morbid poison. With these facts may be connected that of the peculiar liability to infectious diseases (§ 17, 26, 32) shown by persons affected with lesions of the kidney which impair its excernent function; and when such are attacked, they rarely recover. Similar observations may be made respecting various pharmaceutic

poisons which operate through the blood, such as opium, arsenic, and mercury, which act with uncommon, and therefore with dangerous, energy on those whose excreting functions are much impaired, either by structural disease, or by extreme weakness or exhaustion.

In all toxæmic diseases of a severe kind there is a remarkable expenditure of flesh and strength. The changes which the poison induces in the blood tend to spoil it for the purpose of nutrition, the function of which is therefore suspended for the time, and emaciation proceeds with the accelerated decay of the materials of the blood and textures. Hence the importance of affording fresh supplies of nutritious food in such forms and as frequently as the digestive organs will allow. Animal broths and jellies, and farinaceous liquids are commonly the most eligible forms during the continuance of the febrile process; but they may be often advantageously administered in small quantities every hour or every two hours, with wine or brandy, according to the state of depression. The utility of alcoholic liquors in checking the waste of the body, when judiciously administered, may be better understood by a reference to what has before been mentioned with regard to their action in this respect (§ 56). In many fevers the gastro-intestinal mucous membrane is so much irritated that even during convalescence solid food is not borne for a long time, and the restoration of flesh and strength is proportionately slow. In such cases, as well as in others in which alimentation is difficult, I have found great benefit from the use of the cod-liver oil in small doses after each meal, which commonly agrees well even in cases in which the irritable state of the alimentary canal will bear neither strong animal food nor tonics.

CHAPTER III.

SECONDARY OR PROXIMATE ELEMENTS OF DISEASE, CONSISTING OF TWO OR MORE PRIMARY ELEMENTS (§ 304.)

SECTION I.

ANÆMIA.

261. The class of *proximate* elements which have been most generally studied as the subjects of general pathology, are those affecting the circulation of the blood. They comprise at least three of the *primary* elements which have been considered—the condition of the blood and its constituents, the irritability of the organs (§ 110, 120) concerned in its distribution, and their tonicity. A previous acquaintance with these elements will render very intelligible many of the phenomena that result from their combination, but it is necessary to keep in view also the physical properties of the vessels and their contents; for these properties, when altered, become themselves elements of disease. Thus a mechanical obstruction or an enlargement of a blood-vessel contributes to the production of disease as much as a change of vital properties. So it is impossible to understand the effects produced by the presence of too much or too little blood in the vessels, without a due consideration of the mechanism of the circulation.

We shall briefly consider the morbid conditions connected with *deficiency* and *excess of blood* in the vessels, under the divisions of *general* and *partial*, and as attended with an *increase* or *diminution* of the irritability and tone of the moving fibre. It is to be understood that all the proximate elements of disease now to be considered, may occur either as distinct affections or in combination with other maladies.

262. *Anæmia*, or as it has been more correctly termed, *hypæmia*, or *oligæmia*, is the name applied to that condition of the

system in which the predominant character is a *deficiency of blood.* But as together with this deficiency in quantity, there is very generally a remarkable deterioration in quality also, the late Dr. Simon applied to the condition the term *spanæmia* (σπανὸς, poor).

263. The causes which excite anæmia are, various circumstances which injure the blood, or withdraw portions of it from the system (§ 71), and especially such as drain off the red corpuscles, or interfere with their formation (§ 66): of this nature are excessive bleedings, or hæmorrhages; profuse evacuations of fluids which contain in themselves much of the organic constituents of the blood,—as bile and pus for instance; feeding scantily, or on such substances as contain little animal matter or protein; confinement in impure air, dark places, or malarious districts (§ 191); the suffering of certain chronic maladies which deeply affect the constitution, such as scorbutic, tuberculous, and cancerous diseases, structural degenerations of the kidneys, and diseases of the spleen and liver, attended with great enlargement (§ 185, 222, 249): but the commonest cause of all is irregularity of the uterine function, which induces the disorder long familiar under the designation of *chlorosis.* It might seem difficult to understand how this last operates, but an explanation has already been suggested (§ 191): that in many cases the irregularity is a cause, and not an effect of anæmia, is plain from the well known fact that no signs of anæmia occur until cold, over-exertion, mental excitement, or some like circumstance, suddenly checks the flow of the catamenia; it does not return; and then the patient begins to lose colour, and gradually to exhibit the anæmic state. In many cases I have known this to occur with young females who have previously suffered from acute rheumatism, implicating the heart. It appears here that some injury is done to the blood corpuscles and to the powers by which these are reproduced: this is manifested not only by the pallidity, but also by the yellowish and almost greenish hue, which the complexion commonly assumes, and which obviously depends on a discoloration of the textures by the altered blood, as happens in the neighbourhood of a bruised part. The nature of these changes has been already noticed (§ 185-6, 191). In some cases of chlorosis, the appetite is depraved (§ 131); there is such a complete disrelish for animal food and other nourishing articles, and such a craving for sour things, and even for matters destitute

of nourishment, like chalk, and cinders, that it might almost be supposed that the perverted appetite determines the anæmia, by deterring the patient from taking such food as is capable of making red blood; and undoubtedly such perverted appetites, when indulged, must contribute to this result; but as they are not constantly present they cannot be considered the chief cause of the anæmia, in those examples where they do occur.

Anæmia is often symptomatic of various other maladies, particularly of chronic and cachectic affections; but it sometimes occurs without any other manifest disease, and its symptoms then exemplify in a striking manner the way in which the various functions suffer from want of a due supply of the vivifying fluid (§ 183, 185).

The general symptoms of anæmia are weakness (§ 116); muscular weakness, evinced by the faintness, breathlessness, and fatigue following upon exercise; weakness of the heart, shown by the feeble, loose, or thready pulse, rendered very frequent and palpitating by slight exertion, or change of position, and often becoming irregular and failing afterwards; feebleness of the whole circulation (§ 123), manifest in the coldness of the surface of extremities; organic weakness, shown by the loss of appetite, indigestion, torpor of the bowels, and scanty and disordered secretions (§ 172); defective nutrition (§ 211), especially of the muscular parts; and imperfect sanguification, for the blood that remains in the system is diseased, being poor and watery, as well as scanty (§ 185, 222).

264. There are also distinctive physical signs of the scantiness of blood in the body: the surface is remarkably pallid; even the lips, gums, and tongue, show none of their healthy ruddiness. The complexion modifies the amount and kind of the paleness; dark persons often appear very sallow, or even of a yellowish or greenish tint, and those of fair complexion having a ghostly pallor. If blood-vessels are seen at all, it is only the larger superficial veins, which are pink instead of blue, in consequence of the paucity and transparency of the blood in them. In the course of the larger veins, (especially the jugulars in the neck), the thin blood may be heard running with great rapidity, for it is readily thrown into sonorous vibrations (venous murmurs), as it courses through the ill-filled vessels; these vibrations are sometimes sensible to the finger placed lightly on the vein, as a sort of thrilling movement. The same thinness of the blood, connected with an abruptness in the heart's cont[illegible]s (§ 113), frequently causes a

murmur with the first sound of the heart, referable to the aortic orifice: as, however, this murmur varies much in different cases, being scarcely audible in some, whilst it is loud and harsh in others, it is obviously dependent in part on some irregularity or narrowing at the mouth of the aorta, too trifling to give any obstruction or sound when the blood is abundant and of due spissitude, but readily causing vibrations and sonorous gushes when the fluid is thin, and the relations between the size of the heart and arteries are somewhat changed. The rapidity of the motion of the blood also increases the loudness of the murmur; under the influence of an excited heart the systolic murmur sometimes extends far into the arteries, and even again reappears, after it has been lost, wherever the artery presses on other solids, be it ever so slightly, as for instance while passing under the clavicles. The venous current, on the other hand, is more under the influence of gravitation, and its murmur is therefore loudest in the jugulars in the erect or sitting posture.

265. The blood of anæmic subjects is found to be very thin and watery when it is drawn from a vein. It readily coagulates, and forms a very small contracted clot (§ 207), generally covered with a buffy coat. This appearance, which was formerly erroneously ascribed to inflammation, is probably due, as Andral surmised, to a predominance of the fibrin over the red corpuscles, for these are diminished much more than the fibrin, being in extreme cases reduced to one-fifth of their natural amount (§ 185). The albumen is also generally scantier than usual; a remarkable exception which occurs in the anæmia attendant on paraplegia has been already noticed (§ 221).

266. Although the symptoms of anæmia are chiefly those of great weakness or depression (§ 262), there are often others of an opposite character, indicating irritation or exaltation of function. Some of these arise indirectly from the weakness, as for example, pain in the left side and epigastrium, nausea, colic, and diarrhœa (§ 56, 168, &c.), which may be traced to weak digestion leading to the production of sundry irritating matters out of the food which has been used for nourishment. But other more direct traces of excitement sometimes occur, particularly if great loss of blood have happened just before. Various functions of the nervous system are exalted; sensibility becomes very acute (§ 126); there is intolerance of light and sound, with the occurrence of flashes in the

eyes, noise in the ears, a sense of rushing in the head, and various neuralgic pains. The excitomotory nerves are sometimes involved in the irritation, (§ 140, 150), and spasms or convulsive affections of different kinds may be present; or the organic functions may be morbidly excited, and palpitation, spasmodic asthma, vomiting, and other sympathetic irritations, occur. In a few instances, anæmia has been attended with delirium, or mental excitement bordering on it.

267. It thus appears that the functions which are mostly excited in the midst of general depression and weakness, are those of the nervous centres; the generally nervous character of persons in a state of great weakness (§ 113) is connected with this same fact, so that *nervousness* and *weakness* are really almost synonymous terms. No explanation of this apparent anomaly has been to my knowledge proposed; but one seems to suggest itself, in the peculiar distribution of the circulation through the nervous centres. When the mass of the blood is reduced in quantity, the blood-vessels generally contract in proportion, their tonicity adapting their area to the bulk of their contents (§ 120). But the vessels within the skull and spinal canal cannot contract with the same facility, in consequence both of their not being exposed to atmospheric pressure, and of their position mostly within bony canals; they do not shrink as the blood within them becomes reduced in quantity, and therefore they retain more than their proper share of the circulating fluid.* This disproportionate amount of blood in the nervous centres produces different effects, according to the degree in which the heart's propulsive power (§ 111) affects it. Under the influence of temporary palpitation (§ 112), fever, or other kind of excitement, the brain and spinal cord receive an unusual share of the exalted but partial force, through their uncontracted vessels which are among those most open to the heart's impulses. An erethism of some one or more of the functions of these nervous centres (127, 133, 153) is the consequence; and pain, spasm, sensorial excitement, intolerance of light and sound, or sympathetic irritations of some kind or another, take place. In this condition

* This statement is not invalidated by the experiments of Dr. Burrows, (Med. Gaz., April, 1843.) His experiments and expositions very satisfactorily demonstrate the absurdity of the notions expounded in Dr. Kellie's paper, that the quantity of blood in the head is always the same; but it is nevertheless clear that the circulation within the head and spinal canal, especially in man, is affected by losses of blood differently from the circulation in other parts.

the head may be hot and throbbing, the face flushed, and the eyes suffused, whilst the extremities, and the surface generally, are comparatively bloodless, and either cold, or very speedily becoming so on exposure. Epistaxis sometimes occurs, but although bringing momentary relief, may, if considerable, add to the evil, by increasing the anæmia.*

268. On the other hand, if the heart's action is feeble (§ 116) it may be inadequate to propel the blood accumulated in the vessels of the brain: this therefore stagnates, and may cause some of the symptoms of cerebral congestion. Headache and giddiness, relieved by the recumbent posture, drowsiness, impaired mental faculties, obscured vision and hearing, partial paralysis, and, in extreme cases, coma or catalepsy (§ 129, 133, 141) are sometimes produced in this way. In such cases the blood collects more in the veins and sinuses of the brain than in its arteries, for it does not receive enough force from the heart to keep it in full motion in these. This congestion may be only temporary, and ultimately lead to no serious results; but in some instances I believe there does occur an event that has not been noticed by pathologists—namely, a coagulation of the blood in the sinuses, and a consequent permanent obstruction to the circulation through the brain. I have met with several cases corresponding more or less with the following description.

A young female becomes anæmic, and after exhibiting various symptoms of feeble general circulation, with headache, drowsiness, and impaired sensorial functions, she suddenly gets worse; passes into a state of stupor with dilated pupils, (sometimes varied by slight manifestations of delirium,) throbbing of the carotids, and

* Although the chief effect of excitement of the circulation in anæmia is thus directed to the nervous centres, it is by no means confined to them. Other parts in the immediate vicinity of the heart become the seat of increased arterial pulsation and disturbance. Thus a painful throbbing is often complained of in the throat, chest, and epigastrium, even when there is little pulse in distant arteries, and the extremities are cold. To understand these facts, we must bear in mind that when the arteries are full and tense, they oppose their fulness and tension to each contraction of the heart, and that this resistance reduces the strength of each pulse in the vicinity of the heart, at the same time that it continues to propagate it to a distance; but that when the arteries are empty and loose, the heart squirts the blood into them in an unresisted jet, whose force is strong near the heart, but does not extend to distant arteries. Nothing is more common than to find the heart beating with a violence that is distressing to the patient, although at the same time the feet and hands are cold, and the pulse can scarcely be felt at the wrist. These incongruities are essentially connected with the morbid conditions present, namely, a reduced quantity of blood and defective tonicity of the vessels (§ 123).

partial heat of the head; and at length dies comatose. On opening the head, a small quantity of serum is found under the arachnoid and in the ventricles, sometimes with a little lymph (in one case there was none). The membranes are remarkably vascular, but the vessels most distended are the veins, and in the larger of these, as well as in the longitudinal sinus, there is a firm coagulum. In places, especially at the torcular Herophili, this coagulum blocks the whole sinus, the fibrin being separated from the other constituents, and portions of it softened down into that opaque purilaginous matter which was long mistaken for pus, but which Mr. Gulliver has shown to be merely such a disintegration as stagnation in a warm temperature is able to effect, and is probably somewhat of the nature of fatty degeneration. These cases have been taken for instances of meningitis. No doubt inflammation may supervene in them occasionally, but in two cases that have fallen under my notice, there was no adhesion of the arachnoid, deposit upon it, or other unequivocal mark of inflammatory action; yet the fibrinous and bloody concretions in the veins and sinuses were most remarkable for their size and firmness* (§ 213).

It appears to me very probable that these affections originate in the encephalic congestion connected with the anæmia. Fibrinous concretions form on the transverse bands of the sinuses, and increase until they considerably obstruct the passage of the blood: this clearly accounts for the impaired state of the cerebral functions, amounting at last to coma. Reaction (§ 16) may take place, leading to determination of blood, and even inflammation, and thus cause such symptoms of partial excitement as sometimes exhibit themselves; but neither during life, nor on examination after death, are the evidences of excitement so prominent as are those of obstruction and interruption to the cerebral functions. It must be remembered that in anæmia the fibrin of the blood is not diminished in the proportion of the other organic constituents, and it has besides a greater tendency to coagulate than in healthy blood (§ 207). There is a variety of headache which often occurs in persons with scanty blood and feeble circulation, and which seems to have some connexion with these irregularities of the

* A wax model of the sinuses and membranes of one of these cases is in the museum at the London University College. Cruveilhier gives a drawing from a similar case, which, without sufficient reason, he considers as one of cerebral phlebitis. Andral mentions a case of cerebral hæmorrhage in connexion with anæmia; this was probably of the same kind.

movement of the blood through the head. When this affection is accompanied by darkness under the eyes, and a dusky injection of the conjunctiva, it is clearly of a congestive nature; and although increased by exertion and excitement, it is sometimes signally relieved by measures which equalize, as well as quicken the general circulation, as for instance the administration of a cup of hot tea, a draught of ether and ammonia, or by a warm bath. The sudden manner in which the headache ceases is accounted for by the restoration of the circulation through the previously congested vessels.

269. In anæmia of long duration the process of nutrition often suffers (§ 211), but by no means uniformly. The cornea is sometimes ulcerated; probably because, being a non-vascular texture, it the more needs a highly nourishing plasma for its support. The nails and hair also are affected in consequence of the imperfect nutrition; and in young subjects the bones are occasionally found to be deficient in their normal rigidity. In some instances the gums are spongy, and liable to bleed, and hæmorrhage from both this source, and from the nostrils, are accidents of by no means unusual occurrence. The muscles become flabby and attenuated; wounds and fractures do not readily unite; and in some instances spreading ulcers and sloughy sores form spontaneously on the external surface. Emaciation is not, however, a constant result of anæmia; and it is not an unusual thing to see the most pallid subjects, (especially if females,) retain a considerable amount of fat. Dropsical effusion into the cellular texture is a common result of anæmia, when either long continued, or aggravated by additional causes of disturbance to the circulation; and slight inflammation of the pleura or other serous membranes then speedily produces copious exhalation into the closed sacs (§ 222). The researches of Chossat on the effects of inanition on animals in some measure bear relation to this subject; for anæmia is the result of deficient nutrition (§ 63). He found that defective nourishment notably reduced the weight of all the structures of the body, with the exception of those which belong to the nervous system; these were wonderfully little diminished by it. This fact accords with the remarkable activity of this system often observed in persons who have been weakened by low diet and similar influences; and is perfectly explained by the manner in which the vessels supplying the nervous centres monopolize what blood there *is, as pointed out in a preceding paragraph* (§ 267). This ascen-

dancy of nervous function, which was first a temporary result of irregular circulation, becomes however in time permanent from modification of structure; and the condition which might have been obviated sooner by the adoption of measures calculated to regulate the flow of blood, assumes the fixedness and intractability of structural disease. Hence young persons who remain long in an anæmic state, are very liable to suffer from confirmed and incurable nervous affections. Even adult females who suffer from extensive and repeated losses of blood acquire a nervous susceptibility which they never afterwards lose.

270. Anæmia, although ordinarily amenable to treatment, may yet in aggravated forms prove a formidable disease, and even be suddenly fatal through syncope (§ 71), induced by some exertion or additional cause of exhaustion; or it may more gradually lead to death by asthenia, or general failure of the vital powers, often attended with anasarca; or by developing tuberculous (§ 211) or other cachectic diseases to which the individual may be predisposed; or by the singular affection of the head before noticed (§ 267); or by other slower and less marked changes brought about in the nervous centres, and ending in paralysis, insanity, amentia, and epilepsy.

271. *Remedial measures.*—Few disorders afford more striking illustrations of the power of medical treatment than anæmia, especially that variety of the disease which was formerly called chlorosis. The ghastly appearance of the patient, often conjoined with an alarming amount of weakness, is well calculated to excite great alarm in the unprofessional observer, and the pathologist, too, may well be excused for sharing in the apprehension, since he knows that the vital fluid which is essential for the sustenance of every function is so deficient and depraved that healthy life cannot go on. Experience, however, teaches that here the blood-making processes may be restored by the timely and judicious administration of certain remedies of the chalybeate class. In a few short weeks all that was faulty is repaired, and the death-like pallor of the countenance is changed to a ruddy hue. Most of the measures adapted to restore the deficiency of the red corpuscles of the blood in the anæmic state have been already specified elsewhere (§ 193, 216). A nourishing diet, with as much animal food as the digestive powers of the patient can master, aided perhaps by the careful use of stimulants— tonics that best restore the appetite, and the powers of digestion and sanguification—secernents, if called for, to pro-

mote the natural excretions (§ 172 *et seq.* 191), exposure of the patient to the pure air and light of heaven, as freely and as long as the strength and sensibility in the particular case will allow,—avoidance of fatigue, excitement, and all debilitating and exhausting influences; — these constitute the principal points that are to be observed in the treatment.

The adaptation of these plans of treatment to individual cases requires the exercise of much discretion, especially in proportioning the food to the power of digestion, and in selecting such a form of tonic as will not irritate. Where it does not disagree, iron is unquestionably the best remedy; but the preparation of it that is most suitable for exhibition varies considerably with the nature of the case. Where there is no particular fastidiousness of stomach, or tendency to headache and feverish excitement, its more active salts, the sulphate, sesquichloride, acid phosphate, and iodide are the best. The iodine in the iodide tends to keep the secretions free and improves the condition of the capillary circulation: on account of its liability to undergo decomposition it is best given in the form of syrup; under its use I have seen healthy ruddiness restored to chlorotic females in the space of three weeks. In many cases, however, iron cannot be so rapidly introduced as it is when these active preparations are used, for either the stomach is intolerant of the remedy, or the head suffers from the excitement before enough has been taken to produce the desired result. Here it will be found that if the weaker chalybeates, such as the ammonio-citrate, the sesquioxide, the saccharo-carbonate and the acetate, be chosen, and a very small dose (as perhaps half a grain) be given at first, the remedy will be borne, and will eventually, although slowly, produce its beneficial results. One frequent reason for intolerance of iron, as well as of other tonics, even where their influence is greatly needed, is defective action of the excreting organs, evidenced by costive bowels, and scanty high coloured urine. In these circumstances the blood, scarce as it is, is impure also, and the slightest use of a tonic may excite irritation, instead of improving the blood-making process. Eliminating remedies are therefore required, and those which generally answer best are effervescing saline medicines given in combination with iron, and conjoined with the use of a slight daily aperient of aloes or rhubarb. These act on the principle of saline chalybeate mineral waters, and they are eminently successful, not only in decided anæmia, but also in

the numberless modifications of mixed weakness and faulty secretion, that are so commonly met with among the less industrious classes of society. By management of the kind above specified almost every anæmic patient may be brought to bear iron; and the exceptional cases may be treated with calumba or cascarilla and ammonia, and small doses of iodide or bromide of potassium, which will strengthen the stomach, and equalize the circulation, and so prepare the way for the ultimate employment of the more powerful and proper remedy.

Various other tonics may be advantageously combined with the iron in extreme cases of anæmia and debility, especially where these have been induced by hidden hæmorrhage. Of these adjuvants quinine is the most important. M. Petrequin has recently recommended manganese as a useful addition to iron in the treatment of anæmia, and he urges in its favour that it is a natural constituent of the blood. I have in several instances prescribed the syrup of the iodide of iron and manganese (as prepared by some of our leading pharmaceutists) and it has answered very well, but whether better than a simple preparation of iron would have done, I am not prepared to say.

The success of the treatment in anæmia becomes manifest, not only in the return of a healthy colour to the lips and skin, of size to the superficial vessels, and of strength to the pulse, but also by an improvement in all the functions,—breath, strength, digestion, &c. It is a curious fact, that the venous murmurs (§ 264), although diminished, are not so in proportion to the apparent return of colour to the surface; I have before given my reasons for considering these to be dependent on deficiency of albumen as well as of the red corpuscles. This does not accord with the opinion of M. Andral, who reckons the vascular murmurs to be true exponents of the deficiency of the red corpuscles only: but this as a matter of observation loses weight from the erroneous notion which he, in common with Bouillaud, holds as to the seat of these murmurs. They believe them to be in the carotids only: several years since I satisfied myself by numerous and varied experiments, that Dr. Ogier Ward's opinion, that the loudest murmurs are in the veins, is correct.

272. Besides the above-named general measures, indicated in all varieties of anæmia, there are temporary measures required by particular cases; on the one hand, to prevent faintness or excessive

prostration (§ 262); on the other, to subdue nervous excitement (§ 265), and counteract the congestion in the head, which we have remarked upon as likely to occur (§ 267). Diffusible stimulants, such as carbonate of ammonia, valerian, sumbul, ether, wine, and spirits, often prove useful as temporary means of obviating extreme weakness; and in such a state all exertion, even sometimes the merely assuming the erect posture, must be avoided. In anæmia following sudden and excessive losses of blood, as the heart and brain have not then become used to the scantiness of the circulating fluid, this is especially necessary, and if it be not observed, fatal syncope may be induced. Symptoms of nervous excitement (§ 26) require sedatives and narcotics; such as hydrocyanic acid, hyoscyamus, belladonna, and conium; whilst those of nervous depression call for the use of such stimulants as are found to excite the nervous energies, as for example the fœtid gums, oil of turpentine, (especially given in enema), strong tea and coffee, cantharides, strychnia, and electricity (§ 130, 155). But inasmuch as these very symptoms seem to depend on the irregular distribution of the little blood left in the body, they will be the most effectually relieved by removing this irregularity through the unremitting maintenance of warmth in the external surface and extremities, aided by occasional friction, and rest in the horizontal posture, varied with such gentle exercise as the patient can bear; the breathing of pure air, and the judicious use of tepid or cold sponging, or the shower-bath, especially directed on the head and spine (§ 124) will greatly assist in contributing to the same end. The symptoms of decided cerebral congestion and obstruction have generally been treated by antiphlogistic remedies, but with questionable advantage. I have found more benefit to result from a mild stimulant and tonic plan, together with the use of more or less powerful derivants, purgatives, and saline diuretics. Such measures commonly answer best in the congestive headache which often troubles anæmic subjects. Depletion is often earnestly called for by the patient; but it should be avoided as much as possible: where absolutely required from the urgency of the symptoms, cupping to the nucha, or leeches to the temples, or, what is still more effectual, one or two leeches applied to the interior of the nostrils, will answer best. Persons who have suffered long and severely from anæmia, especially induced by excessive and repeated losses of blood, or by menorrhagia or uterine

hæmorrhage, or by inordinate lactation, do not lose their nervous symptoms in proportion as their blood is restored; and this I am inclined to ascribe to some degree of structural change having ensued, as suggested above (§ 268), a more permanent exaltation of the nervous functions being thereby maintained. The treatment necessary in such cases is also of an enduring kind, avoiding all causes of nervous excitement, and using those various means, medicinal and regiminal, which have been formerly recommended as of service in reducing nervous excitability (§ 128, 155). Of the medicines adapted to such cases, the metallic tonics are most deserving of mention; especially the valerianate and sulphate of zinc, the nitrate and oxide of silver, the sulphate of copper, and according to Professor Simpson, the sulphate of nickel.

PARTIAL ANÆMIA.

273. We have the means of becoming acquainted with deficiency of blood in a part of the body in more diversified degrees, than we have of studying deficiency in the whole: in every degree the result is an impaired state of the functions, from mere weakness down to total suspension and death. Thus temporary pressure on the chief artery of a limb soon causes numbness, weakness, and reduction of temperature. The same effects result in a yet more marked degree, when an artery is tied in cases of aneurism, and they are gradually removed as the supply of blood is restored through collateral vessels. In some such cases, the supply of blood is insufficient to maintain the vital properties of the part; then chemical affinities prevail (§ 50), decomposition ensues, and the structure becomes gangrenous and dies. A similar result ensues when the arteries of a limb are obstructed by ossification and coagulation, as occurs in senile gangrene. This event may be produced artificially in animals in forty-eight hours, by injecting charcoal powder into the artery of a limb, the capillaries being thus totally obstructed (Majendie). A sudden obstruction of an artery sometimes occurs in connection with endocarditis, and other diseases of the heart, and Dr. Kirkes has pointed out that this probably results from a mass of fibrin being detached from the interior of the heart, and being then conveyed in the arterial current until it blocks up an arterial branch, and so induces partial anæmia by arresting the circulation there; first there is suspension of function, and subsequently

atrophy, softening, or gangrene. This effect has been observed in the brain, in the kidneys, in the spleen, and in the limbs, and it affords a satisfactory explanation of the sudden attacks of hemiplegia, or of loss of pulse and feeling in limbs, of which I have known several examples.* It is most probable that inflammation and other lesions sometimes terminate in gangrene, by obstructing the circulation, and thus depriving the tissues of a principle indispensable to the maintenance of life.

Many other instances of partial anæmia, short of the extreme cases above noticed, might be cited—thus the perfectly pallid and bloodless condition of the fingers of persons of weak circulation, after cold bathing or long exposure to cold, is a very good example. The vessels are in these so contracted as quite to exclude the blood, and the finger is of waxy whiteness, cold, numb, and almost powerless. A similar condition sometimes obtains in the entire lower extremities in inclement seasons. In individuals liable to be affected in this way, a warm temperature often occasions faintness, and even hemiplegia, by producing deficiency of blood in some part of the nervous centres. In fact many of the symptoms present in those suffering from general anæmia or weak circulation, arise from deficiency of blood being more marked in some parts of the body than in the rest.—The functions of organs also suffer from the same inequality of distribution of blood. In one subject the skin is dry, and perhaps rough and scaly, from paucity of blood supplied to the surface. In another the mucous membranes are principally affected, and dryness of the mouth, fauces, and nostrils, and consequent irritation of these parts, with indigestion and costiveness, may result. In a third, the synovial membranes lack their due supply, and crepitation and stiffness accompany the motions of the joints. It is where the general circulation is weak that pressure is most liable so to interrupt the circulation of any part, as speedily to deprive it of life, so that it ulcerates, or sloughs, as in the instance of bed sores.

Softening, wasting, and degeneration of textures, are also effects attributable to continued defective supply of blood. The former is exemplified in softening of the brain and of the heart, occurring in connexion with ossified arteries: wasting, in the atrophy of parts subjected to continued pressure; and degeneration in the fatty change of the heart and other muscular structures, consequent

* Med. Chir. Trans. 1853.

on impeded supply of blood. The arcus senilis or arciform degeneration of the iris, appears to result from the pressure of the eyelid, which quickens the degeneration of that part. Partial anæmia is concerned in producing many changes of structure that arise under various circumstances. Deficient supply to secreting organs necessarily impairs the amount and quality of their secretions (§159).

The treatment proper for partial anæmia comprises not only measures that restore the supply of blood, but also such others as maintain and equalize that supply by increasing the quantity and improving the quality of the fluid in general. Thus, while the application of heat, stimulant frictions, and the employment of exercise, are practised, to bring back blood into the anæmic part, the remedies for general weakness and anæmia (§ 271) should be brought into action to maintain a more constant supply, and to prevent other parts from suffering in turn from the deficiency. As the duration of partial anæmia is generally of a more temporary character than is that of the general disease, the most efficient remedies are such as act promptly, for instance, stimulants, generous diet, and various mechanical and other appliances calculated to quicken the movement of the circulation. One expedient for accomplishing this latter object deserves especial mention on account of its great utility under particular circumstances; I allude to the use of the vulcanized India-rubber water-cushion to prevent the pressure which occasions bed sores. The same cushion filled with hot water likewise affords a ready means for applying dry warmth to the skin and extremities, when the natural temperature fails, and thus it may aid in the counteraction of local anæmia.

SECTION II.

HYPERÆMIA OR POLYÆMIA: EXCESS OF BLOOD.

274. *Too much blood in the system,* or *in a part,* is a most frequent cause of disease. It implies an undue distension of the vessels which contain it; and a modification of the properties of these vessels, and of the heart, is almost constantly a concomitant of this morbid condition. The chief vital properties of the heart and vessels are irritability and tonicity; excess (§ 114, 121) and defect (§ 116,

123) of these form important elements which modify the effects of excess of blood: and thus is synthetically suggested a distinction (long recognised as most valuable in practice) of the active or sthenic, and the passive or asthenic, hyperæmia: this distinction is applicable to both general and partial excess of blood. Another variety of hyperæmia is characterized by an altered or perverted action of the vessels; this is chiefly seen where the affection is confined to a part, and includes that singular and complex condition —*inflammation*. An enumeration of these important proximate elements of disease (§ 107) is given in the following table. It is not meant that the diseased conditions specified are always separate, or that they consist merely of the elements stated; but these are their most distinguishing features, and especially important in regard to treatment.

HYPERÆMIA: Excess of blood.	General = Plethora	with motion increased = Sthenic	RESULTS.	
		— — diminished = Asthenic		Hæmorrhage.
	Local	with motion diminished = Congestion		Flux.
		— — increased = Determination of blood		Dropsy, &c.
		— — partially increased, partially diminished = Inflammation.		

SECTION III.

PLETHORA—GENERAL EXCESS OF BLOOD.

275. As general anæmia may arise from defective formation or excessive expenditure of blood, so general plethora may proceed either from too much blood being made, or from too little being expended. In either case, the blood accumulates and fills the heart and blood-vessels beyond the usual degree. But this implies a certain activity and health in the processes of digestion and assimilation, and also a freedom from any considerable local disorder. A person with weak digestion rarely becomes plethoric; and one who suffers from a local ailment is commonly warned by an aggra-

vation of this, before the fulness can become general to any great extent.

276. The persons most liable to become plethoric are those who are overflowing with health; who have a good appetite, and indulge it, without paying sufficient regard to exercise and to the excernent functions; and whose digestive powers are in full activity. The bloodmaking process is with them ever in excess; the vessels get more and more filled; and their fulness becomes manifest in the red face, distended veins and large pulse: the heart is excited and labours with its load, especially on any muscular exertion being made; hence palpitation and short breath ensue, with somnolency and indisposition to exertion; but these may attract no immediate notice, and merely lead to inactive habits. The state of plethora, thus gradually induced, may be extreme, without any of the vital functions materially failing, and yet the subject is on the brink of various maladies. It is well if some great secreting organ is first excited under the high pressure, and the system gets relieved through a free discharge, as when a mucous or bilious diarrhœa sets in; or if some unimportant and convenient set of blood-vessels gives way, as when epistaxis, or bleeding piles occur; if one of the great secreting organs, as the liver or the kidneys, fail in its proper function (§ 170, 254), when a bilious attack, jaundice, or a fit of gout or gravel, is the consequence. Any of these results, by establishing a perceptible ailment, serves to disturb the dangerous ease of the plethoric; and by rendering necessary a temporary discipline, saves him from the worse consequences of plethora—apoplexy, or structural disease of the heart, or of the great vessels, lungs, kidneys, or liver.

277. Besides the conditions already noticed, there are other circumstances which may induce plethora. The diminution of a natural or habitual excretion or loss of blood, the drying up of a long-established sore or issue (§ 270), or the removal of a limb; all of these diminish the expenditure from the system, without impairing the bloodmaking process, and so often become causes of plethora, if no local disorder be excited before the vessels in general reach a plethoric tension.

278. The distinction of plethora into *sthenic* and *asthenic* depends upon the different degrees of the strength and irritability present in the motor fibre; this we have already noticed as an

ultimate element of disease (§ 110 and 120, *et seq.*). Where the irritability and tone of the heart and arteries are in full amount, the increased quantity of blood excites these properties to the utmost. Apart from absolute disease, the vital functions are active and energetic in proportion to the quantity of blood which the respective organs receive; when the supply is abundant, the heart's action and the arterial pulse are strong and regular; the secretions are copious; sensibility is keen; contractility powerful and in good tone; animal heat well sustained; and the mental and bodily powers generally vigorous and active. But when the quantity of blood is augmented beyond this, plethora tends to disease; the heart's action gets over-excited; the pulse is frequent, as well as strong and hard; the face is florid and flushed, and the heat almost feverish; the capillaries of secreting organs and surfaces are variously disordered, sometimes excited to excessive secretion, or sometimes beyond, to a state of fulness bordering on hæmorrhage or inflammation; then occur bilious attacks, hæmatemesis, lithic acid gravel, strong and acid urine, and various forms of sthenic gout: the sensibility and sensorial powers may be stimulated by the rapid flow, or they may be diminished by the pressure of the blood on the nervous centres. Attacks arising from these different effects of plethora may occur again and again, alternating with intervals of unimpaired health; but in time the tendency to disorder becomes greater in consequence of the structures and functions recovering less perfectly in the intervals, and if the plethora be continued, it gradually loses its sthenic character, and lapses into the less active variety. If the plethoric state is moderate enough to last for some time without producing immediate disaster, the nutritive function eventually gets to be affected. Some of the superfluous nourishment may be deposited in fat, which deposition is another safety-valve to the plethoric: but even this throws an additional burden on the heart and blood-vessels, which are therefore the more strained and oppressed, and are among the first of the textures to exhibit structural changes, in the form of hypertrophy, valvular disease, atheromatous patches leading to dilatation, aneurism, &c. In this way organic disease may issue out of the continued excitement of sthenic plethora.

279. Sthenic plethora is the form which commonly affects the young, the active, and those who are in prime of life or of sanguine temperament (§ 41). It comprehends a rich state of the

blood (§ 184), and an active condition of the nutrient function (§ 195). Its tendency is to cause general febrile excitement, active hæmorrhages, fluxes, and inflammations.

280. In *asthenic* plethora there is a want of contractility (§ 116) and tone (§ 123) in the motor fibre. The heart and other organs, instead of being excited by the augmented quantity of blood, are oppressed by its load. The pulse may be full, but then it is slow; more commonly it is frequent and irregular or unequal. There is sometimes a tendency to faintness alternating with palpitation; physical examination indicates that the heart is enlarged by the accumulation of its contents beyond what it can expel. The face is purple rather than red; the veins are generally distended; sometimes the extremities are apt to become cold. Most of the vital functions are sluggish, and imperfectly or irregularly carried on. The bowels are torpid; the urine is scanty, high-coloured, or turbid; sensibility is blunted, muscular power low, and the mental faculties dull, with lethargy or somnolency; the spirits are often depressed, and the activity altogether reduced.

281. Asthenic plethora affects principally those who are weakened by age, excesses, or previous disease, and in whom the excreting organs act imperfectly; such imperfect action is a cause, as well as a consequence of plethora. In fact it is the increasing impurity of the blood that tends to convert the sthenic into the asthenic form (§ 278). It is when the blood is not properly purified of the effete matter which forms in it, whether it be stagnant or in motion, that it fails to excite the functions of organs in a regular manner, so that they in consequence become oppressed, sluggish, and disordered, and the morbid condition results in cachæmia as well as hyperæmia. Asthenic plethora tends to produce congestions, passive hæmorrhages, fluxes and dropsies; and if continued, structural changes in some organs, such as dilatation of the heart, enlarged liver, varicose veins, &c. Congestion of the brain, with apoplexy or palsy, headache, or other symptoms of disturbed cerebral function, is sometimes produced; or if there be any organ, the vessels of which are weak from past or present causes (§ 31, 32), this organ is liable to be the first to suffer.

282. The symptoms of asthenic plethora hitherto described are chiefly expressive of a depressed or oppressed state of the functions. Sometimes, however, there arise others betokening excitement or reaction of an irregular kind. The pulse becomes quickened, and

often irregular; the skin is hot or partially perspiring; sickness and vomiting may occur; the tongue gets much furred, and sometimes brown and dry; the excretions are defective, unusually offensive, and often changed in appearance; the complexion becomes dusky, the eyes suffused, the mental faculties blunted by lethargy or confused by low delirium. This is a kind of congestive fever, such as is described by Dr. Barlow as a result of reaction from asthenic plethora. It is possible that this description may have been drawn from cases in which, besides asthenic plethora, some morbid poison (§ 258) has been in operation; but many of the symptoms named may be fairly traced to a congestive fulness of the blood-vessels, combined with an impaired action of the excreting organs (§ 70, 171, &c.); and consequently, with the diseased condition of the blood, which we have described to arise from imperfect excretion (248, *et seq.*). The mere stagnation or imperfect motion of the blood will prevent it from properly undergoing the process of purification, and the elimination of its decaying materials through the instrumentality of respiration and excretion: hence it becomes loaded with urea, lithic and lactic acids, and other effete matters which unfit it for its proper uses, and irritate and disorder the organs through which it passes. The process of reaction, or febrile excitement, which occurs in cases of asthenic plethora, is sometimes more distinctly connected with a specific condition of the blood, as in the case of gout (§ 254), rheumatism (§ 251), and various cutaneous diseases, which assume generally the atonic or asthenic form.

283. *Remedial measures.*—The means already described as useful in effecting a reduction of excess of red corpuscles (§ 192) and fibrin (§ 214) are also suitable for the earlier and simpler states of plethora. In fact, in these states, the blood usually does exhibit this very excess, for which bloodletting, evacuants, and abstinence are the chief remedies. The propriety of bloodletting in extreme degrees of plethora is evinced by the extent to which it may be carried without causing faintness. Thus Dr. M. Hall found, that in patients suffering congestive apoplexy, from forty to fifty ounces might be drawn without producing syncope; whilst in acute inflammations, the *tolerance* is usually less by about ten ounces. But it is not necessary to employ bloodletting to this extent in simple plethora, even when in an extreme degree; the object is then not so much to cause faintness or a sudden impression, as to

relieve the extreme tension of the vascular system, and thus to afford the secreting organs an opportunity of accomplishing the remainder of the cure. It is rarely desirable to draw more than twenty ounces of blood, and in many instances cupping to a small amount over an organ especially congested, will suffice. The beneficial effects of bloodletting are sometimes immediately manifest, although they vary somewhat in the two varieties of the disease. In the *sthenic* kind, the pulse becomes softer, weaker, and less frequent; in the *asthenic*, it often improves in strength and regularity, and sometimes rises to a natural frequency. In simple and recent cases of both kinds, a moderate bloodletting, with due avoidance of the causes of the plethora (so far as that can be accomplished), and the continued use of a little aperient and saline diuretic medicine, will complete the cure.

284. But if the plethora have lasted long enough to produce some of its ulterior effects (§ 282), bloodletting may be an insufficient, nay, in some instances, even an unfit remedy. In both kinds of plethora, medicines which increase the excretions are generally indicated, and the diet must be much restricted; but the particular mode in which the special aim of treatment is to be carried out, varies greatly in the separate forms.

285. In *sthenic* plethora, not only is the blood in excess, but so also are the irritability and tone of the moving fibre. Here, then, besides removing the excess of blood, sedative and relaxing remedies (§ 115, 122) are indicated. Antimonials, salines, digitalis, aconite, and hydrocyanic acid, conjoined with a cool regimen, and spare diet, are found to be serviceable; these are often useful in the treatment of sthenic plethora. Lemon juice may be ranked as a medicine of a lowering kind; it distinctly reduces the strength and frequency of the pulse. The same remedies combined with mercury, colchicum and other like agents, fulfil also another indication; they augment excretions which are defective in consequence of an over-excited state of the capillary circulation, bordering on hæmorrhage or inflammation. If any part should especially suffer, local bloodletting may be requisite.

286. In *asthenic* plethora of long duration, on the other hand, although bloodletting may relieve, it does not recal the lost tone of the over-distended vessels. Tonics (§ 124), and even stimulants (§ 119) may be necessary at the very time that blood is drawn and evacuants used; and such treatment as is calculated to restore

the impaired functions of digestion and secretion, and to improve the depraved condition of the blood may be required to be long persevered in (§ 174). In such cases, the prolonged use of alterative aperients and diuretics, such as mild mercurials, rhubarb, aloes, senna, salines, taraxacum, nitric acid, and iodide of potassium, may prepare the way for the ultimate employment of such tonics as calumbo, bark and iron. In these cases, the mineral waters of Cheltenham, Leamington, and Llandrindod, in this country, of Carlsbad, Marienbad, and Homburg in Germany, and of Vichy in France, are often of great service; first the more saline, which are aperient and diuretic, and afterwards the more chalybeate, which, although tonic, usually contain enough saline matter also to keep the secretions free. Some waters of the latter class, as those of Bath and Wiesbaden, tend to excite torpid and plethoric habits to a critical reaction, thus often bringing on a regular fit of gout (§ 254).

The diet needs to be well regulated in all cases of plethora. In the *sthenic* kind it should be spare, so as to diminish the materials from which the blood is formed (§ 193). Little or no animal food, or that only which is of the lightest kind, such as white fish and chicken, should be used. A moderate quantity of bread should be taken, and if the appetite and digestion be good, a liberal allowance may be made of vegetables and fruit. The "cure de raisins," in which the diet is exclusively grapes and a little bread, is well adapted for cases of sthenic plethora. Fermented and spirituous liquors must be wholly avoided. It must, however, be borne in mind that plethora is an habitual condition of the system, rather than an attack of positive disease, and happening, as it may do whilst the appetite is good, and whilst the functions of digestion and assimilation require a fitting employment, the subject of it is not to be starved by a diet fit for a patient with fever or inflammation. The plan should therefore be one of moderation, which can be persevered in, rather than one of extreme abstinence which might soon injure the health. In *asthenic* plethora there is even more need for caution in the reduction of the diet; and care should be taken to avoid rich and heating articles of food, rather than such as are of a nutritious quality. Even fermented liquors of a light kind may be advantageously used in moderation, if previous habits have established a need of them. As there is commonly much functional weakness of the

digestive as well as of other organs, it is important that such adjuvants as possess no ulterior injurious operation should be employed. Regular exercise in the open air, so far as the strength will permit, is likewise an important aid in restoring tone to the system, and in improving the condition of the blood.

SECTION IV.

LOCAL HYPERÆMIA—EXCESS OF BLOOD IN A PART.

I. WITH MOTION DIMINISHED—CONGESTION.

287. The true nature, and the distinctive characters, of *congestion*, or *local hyperæmia with retarded motion*, may be conveniently traced through the several causes that induce it, all of which agree in combining the conditions here expressed in the definition of congestion, excess of blood in the vessels of a part, with diminished motion of that blood (§ 274). We have already seen that portions of the vessels, and even the heart itself, become congested in asthenic plethora (§ 281); but then it is as a portion of a more general disease. We have now to consider the causes and phenomena of congestion of blood in a part, which may occur independently of general disease.

288. The word congestion means a *heaping together*, and congestion of blood is an accumulation of blood in the bloodvessels of a part. The main and essential seat of congestion is in the capillaries, but it may extend to the veins, or as we shall presently see, may even commence in them. The arteries, however, are not enlarged, and this is the important feature which distinguishes congestion from determination of blood, and inflammation. Blood-vessels become congested, or unduly distended with blood, when their proper elasticity and tone are overcome; and this may happen because an obstruction in the veins prevents the free escape of blood from them; or it may happen because the coats of the vessels themselves are weakened, and therefore yield to the pressure of the blood transmitted to them. The chief causes of congestion may then be classed under these two heads:—1. *That*

of venous obstruction; and, 2, *that of atony of the vessels* (capillaries and veins). We propose to notice under these two heads various instances of congestion, which will serve further to explain and practically illustrate the subject. It is obvious that in congestion from either of these causes, as the blood accumulates in the part, its motion will diminish; for as the great source of that movement is the force transmitted from the heart through the arteries, so long as the arteries remain unenlarged, the force which the enlarged capillaries and veins receive, will be reduced in consequence of being expended upon their greater area.

289. (1.) *Congestion from venous obstruction.*—When an arm is bound up for venesection, the veins are compressed more than the arteries. Hence the veins swell, then the fingers become red, and after a few minutes purple, and the whole limb is swollen from the congestion of blood in its vessels. In like manner, cold applied to the surface of the body affects and contracts the veins more promptly than the arteries which lie deeper, and the capillaries speedily become congested, as is evidenced by the purple colour of the hands and face. Cold also impedes the circulation by increasing the adhesion of the fluid to the walls of the tubes, a mere physical operation, first pointed out by Poisseuille; and probably also by diminishing the activity of those chemical changes which assist the circulation in the capillaries. Congestions are caused in internal organs by obstruction of the veins leading from them. Thus congestion of the brain may be produced by a tight stock or cravat (§ 51), or by a tumour pressing on the jugular veins. Efforts of straining (§ 64), coughing, holding the breath, and asthmatic paroxysms, which impede the flow of blood through the lungs, cause congestions in various parts. Disease of the valves of the heart, which prevents the blood from passing onwards through it, produces fulness of the veins and of the capillaries in both the pulmonic and systemic circulation. Tubercles in the lungs cause congestion of these organs. Obstruction to the transit of blood through the liver causes congestion in the abdomen. The characteristic of congestion beginning with the veins is, that the veins as well as the capillaries are distended: this appearance is obvious during life in cases of aneurism, or any other kinds of tumour compressing the veins of the neck; and after death in the full arborescent appearance of the veins in the congested part.

Certain diseases of the organs of respiration, especially extensive emphysema of the lungs, in which the efforts of expiration predominate over those of inspiration, cause congestions, not merely by opposing the return of blood through the veins, but also by lessening that suction influence which serves to promote its flow towards the pulmonary capillaries at each inspiration. It has been pointed out by M. Berard, (Arch. Gén. de Méd., Jan. 1830,) and by Mr. A. Shaw, (Med. Gaz., July, 1842,) that the circulation in the liver during health, is to a certain extent dependent on this same action; and it may be inferred that the diminution of its power where there is extensive vesicular emphysema affords some explanation of the hepatic congestion that is so commonly combined with this pulmonary lesion.

290. (2.) *Congestion from atony of the vessels.* — This is seen in a great variety of cases. In some of these the atony of the vessels (§ 123) affects the whole system, as is illustrated in extreme debility, adynamic fevers, and the sinking which precedes death. The heart then acts feebly, and without sufficient force for the propulsion of the blood through the whole circuit of vessels; these therefore yield from want of tone, and they do so most where they are the least provided with tonic fibres; that is in the capillaries and veins, and especially those of parenchymatous organs. Here accordingly the congestions appear. The blood gravitates chiefly in parts that are the lowest in position in the body; the vessels of these, in their weak state, yield to the accumulating blood. This occurrence of *congestion in undermost* parts (*hypostatic*) is the distinctive character of the presence of weakened vessels. From this cause the posterior parts of the lungs, intestines, and integuments, are commonly found much congested after long lying in the recumbent posture.

291. In other cases the weakness is local, and does not affect the vessels generally, the weakening influences being applied to some vessels only. *Over-distension* is a common cause of congestive weakness of vessels. Thus after long continuance of the body in one position, the lower vessels yield to the gravitating force (§ 51) of the blood, and become congested. On this account the feet swell after long standing or walking, especially in warm weather. A continued stooping posture, or lying with the head low, may occasion congestion of the brain, headache, giddiness,

and confused vision, and may prove an exciting cause of apoplexy. Remaining long in a standing or sitting position, often causes congestion in the hæmorrhoidal veins, liver, uterus, &c. Where the circulation is feeble, and the tone of the vessels weak (§ 123), these causes of congestion operate more readily and more permanently than where the circulation is vigorous; yet these congestive affections, the mere result of weakness, are often mistaken for inflammations. Many of the pains and ailments of delicate females are of this nature; and although temporarily relieved by depletory measures, are to be permanently relieved only by tonic means (§ 124), which promote the vigour and equality of the circulation.

It must be borne in mind that congestion, mechanically induced, when it lasts long, may so weaken the vessels by overdistension, as to be continued after the original cause of the condition has ceased to operate. Thus congestion of the brain or lungs brought on by a paroxysm of dyspnœa, or of coughing, or by violent straining (§ 64), may not subside with the cessation of the effort; giddiness, headache, pain, and dyspnœa, commonly remain for some time after such attacks.

292. In considering the operation of cold as a cause of disease, we had occasion to notice that it chiefly operates by constricting the vessels of the surface and extremities, and thus throwing the blood inwardly, causing internal congestions by *intropulsion* (§ 77). If this condition is continued long, the tone of the internal vessels becomes impaired, and the congestions do not cease on the restoration of warmth to the surface. Thus a permanent congestion in the lungs, liver, kidneys, or mucous or serous membranes, whichever happens to be predisposed to the state, may result; and this congestion may disorder the function of the part in various ways, or may lay the foundation of inflammation.

293. Malaria (§ 82), and the influences which produce continued and exanthematous fevers (§ 93), seem to have a similar congestive effect with external cold, but it is not so easy to explain how they operate, unless by a directly paralysing influence on the tonicity of the vessels, or by arresting the chemical changes which should take place in the capillaries. The cold stage of these diseases exhibits in a high degree the marks of intropulsive congestion; and it is well known that in ague the congestive enlargements of the liver and spleen are among the most remarkable phenomena exhibited (§ 191). The congestions

that are set up in the febrile stages of fevers, seem to be the chief causes of their inflammatory complications.

294. Another cause of congestion is *over-excitement* of the vessels. It is well known that when a part has been inflamed, the vessels often remain dilated for some time, although the signs of true inflammation are no longer present. This is well seen in the conjunctiva, the throat, and the skin, and in certain ulcers; it is also exemplified by some internal organs. The liver and stomach present many signs of congestion after the excitement of stimulant drinks (§ 56). We may, however, with the microscope, trace the production of congestion by stimulation apart from inflammation.

When a slight irritant, as a weak infusion of capsicum, is applied to the web of a frog's foot, it first causes a slight and very brief contraction of the vessels, chiefly of the arteries (§ 120); then quickly follows enlargement of the same with very rapid motion of their contents: if the application has been very slight, the vessels gradually contract after a while, and return to their natural size. But if the stimulant application be repeated several times, so as to prolong the determination of blood into the part, the vessels do not then uniformly contract. The arteries indeed shrink, but the capillaries and veins remain dilated, and thus illustrate completely the conditions expressed in the definition, excess of blood with diminished motion (§ 287). This dilated state of the capillaries and veins must be partly ascribed to their losing tone after excitement (§ 123), more than arteries do; but the process which I have been describing is accompanied by changes within the vessels also; numerous pale corpuscles adhere to the sides of the capillaries, and so impede the current, and cause congestion by obstruction. Whenever the stimulus applied has been very strong, this obstruction amounts to complete stagnation, and many highly enlarged vessels appear filled with stagnant blood, or rather with an accumulation of red corpuscles entangled in the coherent pale ones. For this reason, the vessels in which the blood is stagnant, are of a deeper red than the others, the red corpuscles being arrested in them whilst the liquor sanguinis passes on. Mr. Wharton Jones has also observed that when the blood thus stagnates, the red corpuscles adhere together in piles or rouleaux, as he had previously observed to be the case with blood out of the vessels.*

* Med. Chir. Trans., 1853.

295. All that has been now described belongs to congestion, and there can be little doubt that the intense and deep redness sometimes seen in congested parts, is principally caused by the absolute stagnation of red corpuscles in the vessels. We shall hereafter see that a similar congestion and stagnation occurs also in inflammation, and may be the only change left by it that can be observed after death, if the inflammation has not existed long enough to produce its other more characteristic results. It is for this reason impossible to discriminate between recent inflammation and some forms of congestion, by direct anatomical characteristics.

296. Congestion occurs in various organs and membranes when their proper secretions are arrested, or suddenly diminished (§ 167). It is very probable that the passage of blood through a secreting organ or surface is promoted by the chemical changes which this fluid usually undergoes therein according to the law of osmotic force resulting from chemical action, noticed by Professor Graham (*Proceedings of Royal Society, June,* 1854). If therefore the chemical affinities of the blood, or of a secreting organ, be deranged, this motive power may be wanting, and congestion of blood and deficient secretion may be the simultaneous result. It is difficult, however, to determine whether the congestion is, in the first instance, the effect or the cause of the defective secretion; very probably it stands in both relations: at least this is the most convenient view to take of the matter for practical purposes. Thus measures which increase the secretion (§ 172), will often remove the congestion; and those which relieve the congestion, generally restore the secretion. There is nothing in this incompatible with the principles already laid down; for the free flow of a secretion helps to unload the distended bloodvessels; and whatever relieves those vessels from their congested state, tends to restore that freedom of circulation through them, which best ministers to the secreting process. And if, as just now surmised, the chemical changes involved in the secreting process aid in effecting the passage of the blood through the capillaries, the activity of the secretion will tend to re-establish the normal state of the circulation.

297. In the first edition of this work, I alluded to some cases of congestion which had not then been traced to any of the causes above specified, although it was not improbable that further investigation might succeed in tracing them to some of those causes. Thus when the blood does not undergo its proper changes in the

lungs (§ 234), its passage through these organs is partially impeded, and it accumulates in the right side of the heart, and in the venous system generally. Congestions on this account form a prominent feature in the pathology of asphyxia. From the observations of Dr. John Reid, it appears that some obstruction also occurs to the passage of the blood through the systemic capillaries, as is proved by the increased pressure in the arteries, indicated by the hæmadynamometer.

I stated that it remained for future observers to determine whether these obstructions are connected with contraction of the vessels (§ 120), increased thickness or cohesion of the blood, or some other simply physical cause; or whether they depend on peculiar vital attractions and repulsions exerted between the vessels and the blood, which are supposed by some physiologists to constitute an important element in the healthy, as well as in the morbid, phenomena of the capillary circulation.*

* Whatever view may be held of the influence exerted by the properties of the blood in impeding its passage through the capillaries, the question is still left open whether the same power in any degree contributes to its motion. That the force of the heart, distributed by the arteries, is generally sufficient to carry on the circulation, is proved by several experiments, of which some performed by Professor Sharpey, are the most convincing. A syringe, with a hæmadynamometer to show the amount of pressure used, was adapted to the thoracic portion of the aorta of a dog just killed, this vessel, having been previously tied immediately above the renal arteries, and the vena cava inferior having been opened at its exit from the diaphragm. Fresh bullock's blood, (deprived of its fibrin by whipping and straining, to prevent its coagulation,) was then injected with a pressure of three and a half inches of mercury, *and it passed out of the vein in a free stream after having pervaded the double capillary system of the intestines and liver.* When the pressure was increased to five inches of mercury, the blood spirted from the vein in a full jet. When the aorta was not tied above the renal arteries, but left free, the same pressure was sufficient to drive the blood through the extensive ramifications of the lower extremities. On the same instrument being adapted to the pulmonary artery, it was found that a pressure of from one and a half to two inches of mercury was sufficient to propel the blood through the capillaries of the lungs, so that it flowed freely from the left auricle or pulmonary veins.

The amount of force thus used is not greater than that which the hæmadynamometer has shown the heart commonly to exert in propelling the blood during life, in the systemic and pulmonary circulation respectively; we thus obtain almost a demonstration, that the heart's power distributed by the arteries is generally sufficient to sustain the process of the circulation.

The chief arguments for and against the existence of vital properties of attraction and repulsion exercised at sensible distances, have been well stated by Professor Allen Thomson, in the article "Circulation," in the Cyclopædia of Anatomy, to which I would particularly refer the student. In addition to these, I would state that in many long and careful microscopic examinations of the circulation in the frog's web, variously modified by different experiments, I have never witnessed any movement of the blood corpuscles,

The researches of my friend Mr. Erichsen (*Edin. Med. and Sur. Journ.* No. 163) on Asphyxia, obtained results which seem in favour

which was not plainly referable to the action of the heart, or vessels. The share which the arteries have in regulating the flow of blood through the capillaries and veins is very evident. When the arteries increase in size, the flow becomes very rapid and general; when they diminish, the flow is tardy, and even ceases in some capillaries; and when the arteries contract, so as to permit no blood to pass through them, the blood which still fills the capillaries and veins, becomes quite stagnant, without a trace of spontaneous movement. When motion begins again, it may always be traced to an artery, which first admits a file of single corpuscles that come "few and far between," and in pulses; afterwards, as the artery enlarges, many rush on in a continuous rapid stream, supplying proportionate motion to the vessels beyond. These observations precisely correspond with others since made by Mr. Erichsen and numerous microscopic observers.

Many of the instances of alleged vital motions in the blood, and in other organic molecules, are referable to mere physical causes. Similar movements may be seen, quite as animated in appearance, on mixing under the microscope two drops of saline solutions of different strength or nature; any insoluble powder placed in these drops may be observed to move, as it were, spontaneously, and the motion continues until the drops have entirely mingled each with the other. Still more lively motions are seen on adding any resinous tincture to water. The blood molecules are no doubt acted upon by the same physical influences that produce these phenomena. But the blood corpuscles are made to move also from another cause; they are not only carried by the current in which they float, but they are often changed in shape by it. Being vesicles, they swell or shrink through the influence of osmose, on any change occurring in the density of the liquid in which they are conveyed; and these changes affect their position and form, and their aggregation and separation, in a manner which readily suggests the idea of their possessing a power of spontaneous movement.

Although it seems unwarrantable to admit any spontaneous motion in the blood-corpuscles, or even any peculiarly vital motory power exercised over the blood by its vessels apart from muscular and tonic contractility, yet it is highly probable that chemical changes which take place in the capillary circulation may facilitate the motion of the blood; and that when these changes are arrested or deranged, some obstruction or congestion may ensue. It is the opinion of many physiologists that there exists in the capillary bloodvessels a power supplementary to that of the heart and arteries, and that this power bears proportion to the activity of the changes taking place in the blood through all the tissues to which the vessels run; and that on a cessation of these changes the transit of blood is impeded. On this subject Dr. Carpenter writes thus:—

"It appears from the preceding facts that the conditions under which the power in question uniformly operates, may be thus simply and definitely expressed. Whilst the injection of blood *into* the capillary vessels of every part of the system is due to the action of the heart, its rate of passage *through* those vessels is greatly modified by the degree of activity in the processes to which it should be normally subservient in them;—the current being rendered more rapid by an increase in their activity, and being stagnated by their depression or total cessation. Or at any rate, to use the more guarded language of Mr. Paget, 'we have facts enough to justify such an hypothesis, as that there may be some mutual relation between the blood and its vessels or the parts around them, which being natural, permits the most easy transit of the blood, but being disturbed, increases the hindrances to its passage.' A physical principle has been put forth by Professor Draper ('Treatise on the Forces which produce the organization of plants,' pp. 22—41), which seems quite adequate to explain these phenomena. It seems fully capable of proof that 'if two liquids communicate with one another in a capillary tube, or in a porous or

of the first of these alternatives, which had been previously suggested (Med. Gaz., Sept. 1835 and 1838). After having shown that analogy is not opposed to the fact that contraction is excited in the minute arteries by the passage of venous blood through them, Mr. Erichsen adds:—

parenchymatous structure, and have for that tube or structure different chemical affinities, movement will ensue; that liquid which has the most energetic affinity will move with greatest velocity, and may even drive the other liquid before it.' Now arterial blood—containing oxygen, with which it is ready to part, and being prepared to receive in exchange the carbonic acid which the tissues set free—must obviously have a greater affinity for those tissues than venous blood, in which both these changes have already been effected. Consequently upon mere physical principles, the arterial blood which enters the systemic capillaries on one side, must drive before it and expel on the other side of the network, the blood which has become venous whilst traversing it: but if the blood which enters the capillaries have no such affinity, no such motor power can be developed. On the other hand in the pulmonary capillaries the opposite affinities prevail. The venous blood and the air in the cells of the lungs have a mutual attraction, which is satisfied by the exchange of oxygen and carbonic acid that takes place through the walls of the capillaries, and when the blood has become arterialized, it no longer has any attraction for the air. Upon the very same principle therefore, the venous blood will drive the arterial before it, whilst respiration is properly going on; but if the supply of oxygen be interrupted, so that the blood is no longer aërated, no change in the affinities takes place whilst it traverses the capillary network; the blood continuing venous still retains its need of a change, and its attraction for the walls of the capillaries; and its egress into the pulmonary veins is thus resisted rather than aided by the force generated in the lungs. The change in the condition of the blood in regard to the relative proportions of oxygen and carbonic acid, is the only one to which the pulmonary circulation is subservient: but in the systemic circulation, the changes are of a much more complex nature, every distinct organ attracts to itself the peculiar substances which it requires, as the materials of its own nutrition, and the nature of the affinities generated, are consequently different in each case. But the same law may be considered to hold good in all instances. Thus the blood conveyed to the liver by the portal vein, contains the materials at the expense of which the bile-secreting cells are developed; consequently the tissue of the liver, which is principally made up of these cells, possesses a certain degree of affinity or attraction for the blood containing these materials; and this is diminished so soon as they have been drawn from it into the cells around. Consequently the blood of the portal vein will drive before it, into the hepatic vein, the blood which has traversed the capillaries of the portal system, and which has given up in doing so, the elements of bile to the solid tissues of the liver." (Principles of Human Physiology, 1853, p. 500.)

Now although I have always been opposed to the notion of peculiar "vital attractions and repulsions" as aiding the circulation, as being repugnant to the simplicity of nature, I am quite prepared to admit the influence of the chemico-physical agency here pointed out by Dr. Carpenter, and which seems to me to be identical with the "osmotic force" of Professor Graham, who traces this force to the chemical action exerted by the fluid on the substance of a porous or membranous system, and he considers it to obtain in the injection of the elementary cells of secreting organs. Further, the transit of fluids through membranes and capillary tubes in general must be amenable to the same law, which seems the more applicable to animal fluids and tissues, as they possess that weak saline impregnation with varying predominance of acid or alkaline reaction, which is most favourable to the excitation of the osmotic force.

"But we may go a step farther, and prove that it (venous blood) actually possesses this power; causing these vessels to contract distinctly, as I have several times observed, on examining under the microscope, the mesentery of rabbits during and immediately after the process of asphyxia. This may be done without much difficulty, as the circulation of these animals, when quite young, continues for many minutes after the struggles of asphyxia have ceased. On asphyxiating a young rabbit, a portion of whose mesentery had been conveniently fixed under a powerful microscope, the following phenomena will be observed to ensue. For about a minute after the struggles of the animal have ceased, the circulation appears to be going on with its usual rapidity; it then gradually becomes somewhat slower, the arteries contracting in size, containing less blood, and assuming a lighter and more tawny colour than before; whilst the veins become congested, and evidently fuller, assuming when viewed by transmitted light, a very beautiful crimson hue. As the circulation becomes more languid, the arteries continue contracting, and acquire a lighter colour, the diminution in their size, and the difference in the quantity of blood contained in them and in the veins, being most marked. The motion of the blood in the capillaries now becomes oscillatory, the whole mass of blood being at each impulse from the heart, slowly propelled forward, and then moving backwards. This to and fro motion continues for some time, and then ceases entirely. On restoring the heart's action by setting up artificial respiration, an impulse was evidently transmitted from the blood in the arteries to that in the capillaries, in a pulsatory and jerking manner, which was soon communicated to the veins, driving forward the whole mass of globules accumulated in them, and gradually becoming more equable and powerful until the circulation was completely restored. I have watched these phenomena most attentively in the mesenteries of young rabbits, and have never observed anything like spontaneous movements in the capillaries: the blood contained in which was invariably most clearly and distinctly influenced solely by the impulses it received from that contained in the arteries. Nor have I ever been able to discover any obstruction in the vessels in consequence of the adhesion of colourless globules to the sides,—a phenomenon that I especially watched for, and which has by several been supposed to occur. The diminution in the diameter of the smaller arteries, and the proportionate difference between them and

the neighbouring veins was most evident, and was such as could leave no doubt in my mind as to the important part that the contraction of these vessels plays in giving rise to an obstruction to the passage of the blood through them in asphyxia; in which I have no doubt that it is the principal, if not the sole agent."

298. These observations correspond perfectly with the many that I have myself made on the frog's web; and, if accurate, they clearly prove that the motion of the blood in the capillaries is chiefly due to the force supplied through the arteries. It is fair to infer that a similar influence is also operative in the capillaries of the lungs. It must, however, be admitted that pulmonary congestion resulting from the exclusion of air from the lungs is greater than can be accounted for by any contraction of the pulmonary arteries under such circumstances. So also the re-admission of air certainly does remove the congestion and the attendant pressure in the veins more suddenly than might be expected to happen from the mere relaxation of tonic contraction. It is therefore highly probable that the movement is favoured by the change which the air produces in the blood, and that this auxiliary influence is no mysterious peculiarly vital power, but simply the operation of the osmotic force resulting from chemical change. This explanation has already been applied to the production and removal of congestions in the secreting organs (§ 296), and may be extended to tissues generally, in which blood-changes are constantly proceeding.

The instances of obstructed pulmonary circulation recorded in Mr. Blake's experiments, in which certain saline solutions (those of salts of soda, silver, &c.) caused death when injected into the veins by obstructing the passage of blood, without coagulating it or arresting the breath, admit of the same explanation.

299. We have considered atony of the small vessels (§ 290) as one chief cause of congestion: it is so, not only by disposing them to yield, and to become distended by the accumulation of blood, but also by rendering them unfit to transmit the force of the current in its proper direction. Vessels which have lost their tone become inelastic and tortuous, and the very accumulation of blood in them, opposes an increasing obstacle to its passage through them. The physical principle to which I now refer is not generally understood, and I will therefore illustrate it by describing some experiments.

300. To one of Read's enema syringes, a tube with two arms

was adapted: to one of these arms another brass tube two feet long was fitted, having several right angles in its course; to the other was tied a portion of rabbit's intestine, four feet long, and of a calibre (when distended with water) double that of the brass tube. The intestine was then placed in curves and coils, avoiding angles and crossings which might obliterate the canal. The discharging end of both tubes was raised to the same height, that of the intestine being kept open by a short tube of metal. The tubes were then both filled with fluid by successive strokes of the piston; and when they both began to discharge, the quantity that passed from each in a given number of strokes, was ascertained. Without entering upon details, it may be stated that the small metal tube discharged from two to five times the quantity that the larger or membranous tube did; the difference being greatest when the strokes of the piston were most forcible and sudden, the intestine then, although much swelled at its syringe end at each stroke, conveying comparatively little water. The difference was further increased by raising the discharging ends higher; when both ends were raised to the height of eight or ten inches, the gut ceased to discharge at all, each stroke only moved the contained column of water so far that it could subside again without overflowing. On increasing the force of the stroke, the part of the intestine nearest to the syringe, burst.

This experiment was repeated with various modifications, of which I will mention one; a metal tube was used two feet eight inches long, and with a bore of three-eighths of an inch, and a portion of dog's intestine of the same length, but which when distended, was of double the diameter. The orifice of the metal tube then passed three times more liquid than that of the intestine.

301. These experiments show that flaccidity and increased length and size in a tube offer impediments to the passage of liquid through it; and although in the experiments, the difference between healthy and relaxed or congested vessels is exaggerated, yet by them enough is really proved to warrant the conclusion that increased tortuosity and number of vessels in a congested part, greater mass of their contents, and atonic flaccidity of their coats, do form additional obstacles to the passage of the blood moving in them, although the amount of the opposition varies according to the state of the circulation.

302. These experiments serve to illustrate a principle that is not

generally kept sufficiently in mind in the considerations of animal and general physics; the *loss* or *neutralization* of *force, by misdirection.* The bloodvessels in their healthy condition are so constituted as to make the most of the heart's propulsive power, and transfer it throughout their whole length: but when dilated, tortuous, flaccid, and otherwise altered, they misdirect and exhaust it: it is then, (like the force of the syringe in the experiment with the intestine,) partly expended in distending and dilating the nearer portion of the tubes, whilst a sufficiency of force does not remain for the onward propulsion of the blood, which therefore stagnates and accumulates in the congested vessels. We shall have other occasions to revert to this principle, since by it may be explained many anomalies of unequal circulation. It is probably often concerned in keeping up congestion which has been for some time previously established by other causes; and it may sometimes be the means of perverting an increased flow through the arteries, which otherwise might sweep away the congested blood, —into that mixture of opposing forces, which exists in inflammation. The conversion of congestion into inflammation frequently occurs in circumstances that bear out these views.

THE SYMPTOMS AND EFFECTS OF CONGESTION.

1. *Effects in the congested part.*

303. When an arm is tied for venesection, the parts beyond the ligature become congested. At first the hand feels rather warmer than usual, and somewhat tender, in consequence of the distension of its vessels with warm blood, but it soon becomes numb, cold, and weak, showing that the arrest of circulation has lowered its vital properties. In like manner, simple congestion generally impairs the vital powers of internal organs, although the unusual distension of their textures by the increased mass of blood, may cause partial excitement. Natural contractility and sensibility are lowered, whilst pain (§ 126), spasm (§ 114), and morbid sympathies (§ 149), are commonly produced, but in a form that is much less distinct and constant than in inflammation or determination of blood. Thus congestion of the liver is sometimes accompanied by pain or tenderness; but sometimes it is without either. Congestion of the stomach sometimes causes gastralgia, nausea, vomiting,

and altered appetite; but these symptoms are often absent when the obvious amount of disease of the liver or heart, and the subsequent occurrence of hæmatemesis, leave no doubt that the stomach was congested. The same remark applies equally to the kidneys, the uterus, the brain, and other organs. We often see the tonsils and uvula congested and enlarged, without pain or soreness. Impaired nervous and muscular functions are more constant concomitants of congestion than pain, or symptoms of irritation of any kind.

304. The natural secretions of congested parts are sometimes at first augmented, as in congestion of the conjunctiva and Schneiderian membrane from cold; but more generally they are diminished, as in bronchial congestion, (dry catarrh,) and congestion of the liver and kidneys. Very commonly, congestion leads to an increased transudation from the whole of the distended capillaries, expressed in effusions of the watery and saline part of the blood, which are more or less impregnated with albumen, and sometimes even with fibrin, as exemplified in the fluids of fluxes and dropsies.

The means by which this effect of congestion is brought about seem to be chiefly of a physical nature. The portions of the vascular apparatus most immediately concerned in supplying the secreting structure, appear to be the midmost of the capillaries, which are often so turned about and convoluted, that they receive the chief force of the current from the arteries. But when the vessels leading to these middle capillaries are congested, they too become tortuous, yielding, and loose, and much of the force derived from the heart is expended in effecting their dilatation, and is therefore intercepted from the capillaries in immediate connexion with the secreting surface or cells;* these are then in the condition of the distant end of the intestine in the experiment related above (§ 300), not duly receiving the force of the current.

* It may seem that this is taking too mechanical a view of the process of secretion; but be it remembered that I do not ascribe secretion wholly to mechanical agency, but only assert what is known to be a fact, that a due force of the capillary circulation is a condition favourable to the process. In formerly inspecting the beautifully injected preparations of the late Mr. Dalrymple and of Mr. Toynbee, I was particularly struck with the distribution of the capillaries of secreting surfaces, such as mucous and synovial membranes. These capillaries run pretty straight from the minute arteries, until they end in loops and ampullæ on the surface, the returning vessels passing back as straightly. The physical effect of this provision is obviously to direct the chief force of the blood's movement on the terminal loops which supply the secreting surface.

The essential effect of congestion is thus to impair the natural process of secretion.

305. But the distension of the congested capillaries sometimes leads to a general exhalation of the more watery part of their contents, which mingling with the natural secretion, renders it watery and sometimes albuminous. Thus congestion of the bronchi sometimes ends with bronchorrhœa. Congestion of the intestines causes diarrhœa; congestion of the uterus, leucorrhœa; congestion of the kidneys, watery and sometimes albuminous urine; congestion of the lungs and pleura, hydrothorax; of the heart, hydropericardium; and of the abdomen, ascites.

306. The element of congestion chiefly concerned in the production of these effusions, is extreme distension of the vessels. Such effects are less commonly found, therefore, in mere hypostatic or gravitative congestions (§ 291), in which the distension is inconsiderable, but they commonly result from congestions brought about by venous obstruction (§ 289), especially when these occur suddenly, and whilst the vigour of the circulation is not impaired. Thus the congestions connected with diseased heart or liver, and produced by acute attacks or other additional causes of obstruction, especially in plethoric subjects, if not soon removed, are pretty sure to end with dropsy, flux, hæmorrhage, or inflammation. The circumstances that determine which of these results shall ensue, will be considered when we come to treat of them specifically as elements of disease; but it may be mentioned that besides distension of the vessels, the condition of the blood has an important influence; a watery state promotes the transudation (§ 222), whilst a highly albuminous and fibrinous state (§ 195) causes the blood to bear more pressure before its watery parts pass through the coats of the congested vessels.

307. The same circumstances also affect the character of the effused fluid. Where the blood is poor, and the watery parts pass easily from the congested vessels, even without much distension, these contain but little albumen. But if the blood abounds in the protein compounds, and more pressure is required before much effusion takes place; then, when the fluid is effused it often contains, not only albumen in large proportion, but self-coagulating lymph also (§ 211). Thus I have seen the fluid of the pleura and pericardium, in rapidly fatal obstructive mitral disease, coagulate spontaneously into a fibrinous crassamentum, when removed from

the dead body. The gelatinous-looking masses of lymph often found in the peritoneal sac of the abdomen and pelvis in ascites from contracted liver, I have no hesitation in referring to the same origin.*

308. Fluxes arising from congestion of high tension exhibit an unusual amount of animal matter of an albuminous or mucous kind, as instanced in bronchorrhœa, mucous diarrhœa, and leucorrhœa. I have been induced to suppose that the polypous concretions and pseudo-membranous films occasionally effused on mucous surfaces may result from long-continued congestion, with a highly fibrinous state of the blood (§ 195). I have seen these evacuated from the air-tubes, in one case, and in several others from the intestines, from time to time, for months, and even years, without the existence of symptoms of inflammation, but under circumstances which rendered it probable that congestion was present. Extensive disease of the heart existed in the former case, and disease of the liver, or amenorrhœa, in the latter.

309. Several years ago I referred albuminous urine (§ 249) to congestion of the kidney; and this view has been subsequently confirmed by some experiments of Dr. G. Robinson. The following were the considerations that led me to my conclusion:—1. The urine often becomes albuminous during great embarrassment of the circulation in cases of organic disease of the heart or lungs (§ 289), when the kidneys are otherwise healthy. 2. I have in many instances observed temporary albuminuria during the cold stage of ague, and in the congestive stage of eruptive fevers. 3. In granular degeneration of the kidney, the amount of albumen in the urine is augmented by circumstances that cause congestion of the kidney, and is reduced by remedies suited to remove the condition. 4. The most common form of Bright's disease of the kidney presents, in its earliest stage, the appearance of a highly congested structure, and it is excited by causes calculated to produce congestion, such as frequent irritation of the kidneys by stimulating liquors — leading to the congestion of exhausted tone (§ 294); continued exposure to cold, especially after the kidneys have been thus excited — leading to the congestion of intropulsion (§ 292):

* This is the true pathology of the "fibrinous dropsies" of Vogel and other German writers. Mr. Gulliver has found that even thin serous effusions, of low specific gravity, will sometimes form a coagulum under certain circumstances; as for example when two specimens are mixed together.

scarlatina probably produces the same result by first irritating the kidneys, then inducing congestion in them. 5. Albumen is most abundant in the urine in the congestive (first) stage of Bright's disease—the vessels becoming more or less obstructed in the progress of the disorder by the deposit of fibrin with granular cells in the tubules, and in some instances, around them, which deposit at the same time perpetuates some degree of congestion, whilst the proper secreting structure is in a degree displaced.*

310. From what has just been stated it may be inferred that congestion, if long continued, may affect both the nutrition and structure of textures. It generally tends to cause abnormally increased deposit in them, constituting a variety of *hypertrophy*, or overflow of plastic matter. Thus, where diseases of the heart cause congestion, there is an increase in the weight of the viscera generally, and more particularly of the lungs and liver. (Clendinning.) The enlargements of the liver and the spleen induced by long continued attacks of intermittent fever (called ague-cake) may probably be referred to the congestion which this disease unquestionably induces (§ 293). I have known a similar enlargement of these organs to ensue after long-continued exposure to cold and damp (§ 77, 292).

311. But the hypertrophy that results from congestion is probably not of a uniform kind, comprising equal enlargement of all

* The secreting structure is partly diminished in another way also. The granular deposit presses not only on the blood-vessels, but on the uriniferous tubuli too; and wherever it totally obstructs them, their office ceases. These tubuli becoming distended, form the serous cysts so commonly found in granular kidneys, and sometimes in those which are not granular. The cysts contain serum, or a jelly-like matter, with little or no urine; and this fact has been urged against the view that they are dilated uriniferous tubes. The removal of the objection, however, is not difficult. The secreting function of the kidney lies in nucleated cells lining the tubuli, (Bowman); growing, filling, and bursting, as these cells do, by imbibition from adjoining vessels, this process, which is that of secretion, must be stopped when the cells are themselves pressed on by an accumulation of their own secretion, which cannot escape; but a serous exudation from the bloodvessels still goes on, displacing by osmosis the urine, and at last distending the duct into a cyst. The same explanation applies to the formation of the serous cysts of the liver. The view also accounts for retention of urine or bile leading to the suppression of the secreting power of the kidneys or liver.

The above note appeared in the first edition, but it expresses what still appears to me the true view of the origin of cysts in the kidney, and it corresponds with an opinion subsequently advanced by Dr. George Johnson, in a paper read to the Medico-Chirurgical Society. At the same meeting a communication from Mr. Simon alluded to the cysts as being enlarged epithelial cells, developed in consequence of the obliteration of many of the tubes.

the textures; arising as it does from an effusion of lymph out of the most congested vessels, it is an intervascular deposit — at first mottling and exaggerating the natural appearance of the structure, as seen in the nutmeg liver and in the early soft stage of granular degeneration of the kidney—afterwards contracting and compressing the structure, and ultimately causing its condensation and atrophy, whilst the new deposit itself forms a granular or nodulated texture of low vitality (§ 211).

312. Such I believe to be the nature and origin of some varieties of cirrhosis of the liver, and of granular degeneration of the kidney. The diversities which these structural diseases present may often be traced to their degree of advancement, or to the extent to which they involve the textures; and an argument in favour of their having their origin in congestion may be found in the fact that they are commonly seen to be most advanced and extensive in the most dependent parts of the organs; as the lower margins of the liver, where of course congestion is promoted by gravity (§ 290). It is however highly probable, that these plastic products of congestion are also, in some cases, more or less developed, and still further modified, by determination of blood or inflammation, and by peculiar composition of the blood itself. Thus in some instances the deposit exhibits a fibrous or closely compacted granular character, and is firmly adherent to the investing membrane, which is more the character of an inflammatory product. In others the deposit is loosely granular, or in irregular cells, often with a predominance of fat globules in it, and with little cohesion: this resembles the degenerative condition of the plastic effusions found in scrofulous or cachectic states.

Long-continued congestion in the lungs may cause hypertrophy of the intervesicular and interlobular texture, and in some cases, even partial consolidation of the vesicular structure itself. Such changes are frequently met with in connexion with long-standing disease of the heart, and occur most commonly in the posterior parts of the lungs, and near their roots, which are the most vascular parts. In the membranes of the brain, and in the capsules of the heart, liver, and spleen, opaque thickening is often seen along the course of the bloodvessels, especially of the veins; apparently the result of the overflow of nutritive matter from these vessels.

2. *Effects of local Congestion on the system.*

When a congestion is extensive, it has constitutional as well as local effects. In proportion as blood accumulates in excess in a part, it leaves the rest of the body with less than its proper share, and so causes the limbs and surface generally to give various indications of weak circulation and want of blood. Thus with considerable congestion of the liver, lungs, or brain, the surface is generally pallid and chilly, the pulse is weak and small, the extremities are cold, there is a peculiar feeling of languor or weariness, and all the vital functions are indifferently performed. A similar state of the system may be produced artificially, by applying a tight bandage around both thighs at once, or even both arms in a weak person: the limbs beyond the ligature become congested (§ 289), and a deficiency of blood is left in the rest of the body. The extreme of this condition is seen in the cold fit of an ague, in which extensive internal congestions are essential pathological states (§ 293). In this, as with other extensive congestions, more especially if suddenly induced (as by cold, § 294), reaction often ensues (§ 16), causing quickened pulse and circulation, hot skin, and other phenomena of fever. Where this reaction is vigorous, it may fulfil the object for which it is designed by Nature, by sweeping back the congested blood into the circulation, and so restoring the balance. Where, however, the reaction is weak, it fails to remove the congestion, but constitutes instead a low feverish excitement, often remittent in type, accompanied by depraved state of the functions, foul tongue, impaired excretions, and restless nights, and this state of things may continue for an indefinite period, until a critical evacuation by sweat, urine, or diarrhœa (§ 171) terminates it, and with it the congestion that had led to the disorder. In other cases, there is no appearance of reaction; but the congestion, if extensive, is not without its injurious constitutional effects: the stagnant blood, unpurified and unrenovated, becomes gradually injured in its composition; and not only unfit for further use in the economy, but a source of contamination to the rest of the nutritive liquid (§ 191), and a cause of cachexia in the system at large. Extreme results of this kind are presented in the slow operation of malaria upon persons who are continually exposed to the noxious influence (§ 85), and in the low apyrexial congestions which precede typhoid pneumonia: but slighter examples

are more commonly and frequently offered in patients whose general health has suffered from habitual congestion, and in whom the loaded and vitiated excretions, which, even without fever, continue to be thrown off, afford evidence of a process of decay in the animal fluids,—the necessary consequence of imperfect purification.

REMEDIES FOR CONGESTION.

313. The most important measures to be adopted for the removal of congestion are such as are addressed to the causes of the disorder. Thus the loosening of a ligature, or the reduction of a tumour, compressing a vein; the moderating the inordinate and inefficient action of a diseased heart; the restoration of the secretion of the liver (§ 172),—all severally tend to diminish congestions resulting from these different causes of venous obstruction.

314. So, also, in the treatment of the congestion of atony or weakness of the capillaries, it is most important that the circumstances which have caused the condition should be removed. In many cases over-distension from gravitation may be at the bottom of the mischief (§ 296); then change of posture gives relief. In congestive fevers, and other states of long-continued weakness, it is on this account beneficial to change from time to time the position of the patient, from supine to prone, or to lying on either side. Where there is congestion of the head, this part should be supported high. The recumbent posture gives much relief in congested hæmorrhoidal or uterine vessels; and it may be seen to reduce the swelling of varicose limbs.

Pressure may sometimes be made a remedy for congestion, by supporting the weak vessels and promoting their contraction. This forms a chief part of the useful operation of bandages, adhesive plasters, and even of poultices, in various external congestions. Pressure probably might be more extensively applied in these cases, and even also in others where there are internal congestions, in the modes suggested by Dr. Arnott, through the instrumentality of mercury, or by the soft slack vulcanized India-rubber air or water pad.

Friction is a modification of pressure especially suitable to some forms of congestion, being calculated to communicate the motion that is defective, as well as to support the weak vessels. It is

obviously useful in external congestions caused by cold; and sometimes also in visceral congestions, as those of the liver and abdomen generally. Exercise operates somewhat in the same way.

315. Another class of remedies for congestion comprehends such influences as promote the contraction of the dilated vessels by augmenting their contractility or tone (§ 124). It is in this way that astringents and cold operate; as when solutions of alum, sulphates of zinc or copper, acetates of zinc or lead, and infusion or decoction of oak bark, catechu, kino, and nutgalls, are applied in congestions of the conjunctiva, throat, rectum, and vagina. The most obvious portion of the action of bark, quinine, and arsenic in the cure of ague, depends upon their reducing the great visceral congestions, which form the most remarkable, and perhaps the most important pathological element of these disorders.

316. The utility of astringents in congestion is limited by the fact, (demonstrable under the microscope,) that they commonly contract the arteries more in proportion, than the capillaries and veins which are the distended parts in this state. Hence their application may chance still further to arrest the motion of the blood, and so increase the congestion. A reaction, however, sometimes occurs, which converts the operation of the astringent into that of a stimulant, which is another of the remedial powers adapted for the relief of congestion. The same remark applies also to cold: and with even more certainty and force, inasmuch as this agent causes a physical obstruction to the flow of blood, in another manner formerly described (§ 296).

Stimulants are sometimes remarkably effectual in removing congestions. Thus a diluted spirit lotion applied to a congested conjunctiva, a capsicum gargle to a congested throat, a stimulating wash or ointment to a purple sore or surface, often prove signally remedial. Other congestions may be dispelled by exciting the general circulation; a draught of stimulant medicine, or of any hot liquid, often relieves the pulmonary congestion which has induced a fit of asthma; a congestive headache is sometimes mitigated by similar means. Well regulated exercise tends to disperse congestions in various parts. Agents, which specifically excite particular organs or parts (§ 173) are often useful in removing congestions from them. Thus mercury is, to a certain extent, a remedy for a congested liver; some diuretics, such as digitalis and can-

tharides, are remedies for congested kidneys; squill, benzoin, ammoniacum, and other expectorants, for bronchial congestion.

317. The influence of stimulants on congestion may be directly observed by the microscope. When a solution of capsicum is applied to the web of a frog's foot, congested from previous irritation, it causes an enlargement of the arteries, and an increased flow of blood to and through the congested vessels. This flow restores motion where it was deficient, sweeps away the accumulated blood, and, in some instances, causes the vessels to contract afterwards to their natural size; so that then the congestion is completely removed and the cure complete. In other instances, however, the stimulation fails to clear the congested vessels; the enlarged arteries pour more blood into them; and if this does not overcome the obstruction it increases the hyperæmia, and, as we shall afterwards see, may even convert it into inflammation. Thus it appears that stimulants as well as astringents, although occasionally proving suitable and effectual remedies for congestion, sometimes tend to increase it; this latter they are most likely to do, when the congestion is extensive, or of long continuance, or when its causes are still in operation.

318. Under such circumstances, congestion is best relieved by the adoption of another course; the employment namely of depletion, and various evacuants. Bloodletting, by puncture or incision of the congested parts, enables the distended vessels to unload themselves, and in this way they may recover their natural size; the utility of this expedient is proved when scarifications of congested conjunctivæ and tonsils are made, and when leeches are applied to a congested os uteri. The blood is, however, more usually drawn *from the vicinity* of the congested part, as when cupping, or leeches on the chest or side, are employed for congested lungs or liver;* or over the sacrum for congested uterus; or when the anus is leeched for congested intestines. Or, without actually shedding the blood, it may be drawn away from congested parts by derivation; that is, by agents which cause determination of blood or congestion in other parts; as dry cupping, mustard poultices, and other stimulating applications to the surface, and by

* It is singular how quickly congestions may be reduced by these means. I have known a congested liver, which reached from the umbilicus to the fourth right rib, (as traced by percussion,) reduced in twelve hours to its normal dimensions by cupping and free purging. Piorry describes a still more speedy reduction of the liver in ague, by the influence of the sulphate of quinine.

purgatives and other evacuants from the interior. A still more powerful agency of the class of derivants is the removal of atmospheric pressure from a limb by enclosing it in an air-tight vessel, and thus partially exhausting the air. This plan was invented by Dr. Arnott, and has been lately used by Sir James Murray and several French practitioners.

These measures, then, act by inducing determination of blood, or even inflammation in another part, and so *drawing away* blood from the congested structure. Other means however may be employed, which prevent or remove congestion by *damming up* the blood in other parts, and so induce a *counter-congestion.* It has long been the practice of some to attempt to stop a fit of ague by applying a tourniquet to the thigh; and Dr. Buckler of Baltimore, led by a popular proceeding of a similar kind, has called the attention of the profession to the general utility of the remedial measure which he terms *hæmostase;* this consists in the temporary application of tight ligatures to one or more limbs, which are thereby congested so much, that there is not blood enough left in the circulation to supply the originally congested vessels, so that when these are relieved of the pressure, they contract and expel the accumulated blood. I have employed this plan in several cases in which temporary congestions were produced in the lungs and liver, and sometimes with a very marked effect; but it has little influence on congestions which have long been formed, and acts chiefly on the distribution of blood in the larger blood-vessels.

319. The operation of several of the foregoing agents, employed in combination or in succession, is generally more effectual than that of either used alone, in the cure of congestions. Thus congestion of the liver may resist the action of mercury, and may even be aggravated by it (§ 294), until the vascular distension has been partially reduced by local blood-letting or derivation; then the mercury increases the secretion, and relieves the remaining congestion. Congestion of the kidneys is augmented, rather than diminished, by the employment of diuretics, which fail when used in the first instance to increase the secretion of urine, and sometimes only render it more albuminous (§ 304). But after some relief has been secured by cupping the loins, and the administration of hydragogue purgatives and diaphoretics, then certain diuretics, particularly digitalis and cantharides, cause a freer flow of urine

less loaded with albumen. This point might be further exemplified; but it is unnecessary to multiply instances.

320. The cause of congestion being, in many instances, atony of the vessels (§ 290), the mischief may often be counteracted by circumstances which augment the tone of the vessels, locally or generally. Thus cold, astringent, or, occasionally, stimulant applications, brace the fibres and invigorate the circulation in a part (§ 124), and so render it less liable to congestion from disease; general tonic measures operate in a similar way on the whole system. The efficacy of bark and arsenic in preventing, as well as in removing the internal congestions of ague, probably depends on the power of these medicines to augment the tone of the vessels of the affected parts (§ 315), so that they no longer yield to the distensive accumulation of blood within them. A similar virtue seems to be possessed, in some degree, by iodine and bromine and their preparations, especially the iodide and bromide of potassium; under their use the disposition to local congestions is diminished, and such as are formed are sometimes dispersed, as is exemplified by their external use in lepra and other congestions of the skin, and by that of iodide of potassium in congestive headache. Mineral acids and other tonics have a like effect in cases of general weakness. The treatment best calculated to remove the results of congestion will be most appropriately considered under the heads, HÆMORRHAGE, FLUX, DROPSY, and INFLAMMATION.

SECTION V.

LOCAL HYPERÆMIA—EXCESS OF BLOOD IN A PART.

II. WITH MOTION INCREASED—DETERMINATION OF BLOOD.

321. Numerous examples of this kind of active hyperæmia are presented in health as well as in disease. The face and neck in blushing, the uterus and breasts at the periods of gestation and lactation, the gums during the process of dentition, the antlers of the stag at the season of their development, are instances of local determination of blood occurring in health. The increased number and size of the bloodvessels, in these cases, manifested in the

vascular redness, show the increased quantity of blood in the part; and the stronger pulsation of the arteries leading to the part indicates the augmented motion of that blood (§ 274).

322. In disease we meet with many examples. Determination to the head is one that is familiarly known; and it well displays one of the characteristics of the condition in the enlargement and throbbing of the carotid arteries. I have witnessed this phenomenon in a great variety of cases. One patient was subject to attacks of determination of blood, which caused him so much suffering and loss of moral control, that he cut his throat to destroy his life. Whilst recovering from the wound, attacks sometimes came on; first with beating of the carotids, then with flushing of the face and head, suffusion of the eyes, and sensations of distraction in the head. In the slighter attacks, these symptoms would all pass away in a minute or two. I have, in several cases, observed the same symptoms usher in the paroxysms of mania. Fits of epilepsy and convulsive hysteria are immediately preceded by throbbing of the carotids, which shows that determination of blood is the proximate cause of the paroxysm. Drs. Darwin and Parry relate cases in which convulsive fits were prevented by pressure on one of the carotids; and I have practised this expedient with success in several instances. Many of the epileptic patients whom I have questioned have stated that the fit is always preceded by palpitation, which, for reasons before explained (§ 266), is very apt to determine blood to the head. But without the patient being conscious of palpitation, there may be determination of blood to the head; and I have found this to be so commonly present, in various kinds of disorder which affect the nervous centres, that I believe it to be the common immediate cause of sudden paroxysms in such. Infantile and puerperal convulsions are probably to be included amongst the cases referred to in this remark, although they may be connected with very different conditions of the vascular system in the matter of fulness, and are to a great extent dependent upon an imperfectly purified condition of the blood itself (§ 249).

323. But the most common cases of determination of blood are those caused by the application of stimuli. Thus heat causes a flow of blood to the surface; snuff, to the nose and eyes; spices in the mouth, to the salivary glands; food in the stomach, to its secernent vessels; purgatives, to the vessels of the intestines, and those of glands connected with them; diuretics to those of

the kidneys, &c. &c. In fact, the operation of most medicines is connected with their causing an increased flow of blood to particular organs or surfaces; and there are few diseases in which local determination of blood does not take place. We shall find hereafter that it occurs in inflammation as a part of that complex process; but Dr. Parry was wrong in supposing that inflammation consists in determination of blood alone.

324. Now, what is the physical cause of determination of blood? In some cases, increased action of the heart (§ 112) may propel the blood with unusual force and in unusual quantity to the arteries in its immediate vicinity: more particularly when there is little blood in the system, and that little accumulates in and near the heart, as in cases of anæmia (§ 266), or in the commencing reaction consequent upon great congestion of internal organs, as in the beginning of the hot stage of fevers: determination of blood to the lungs and bronchi, to the neck, and to the head, is a common result of inordinate action of the heart. But in many of the examples above cited (§ 323, 324), local determination takes place without any increase of the heart's action, and must therefore be due to another cause.

Is this determination of blood then caused by *increased* action of the arteries? The only active property which we know these vessels to possess is that of slow or tonic *contraction* (§ 120); such contraction of arteries, leading to any part, would diminish instead of increasing the motion and quantity of blood proceeding to it (§ 294). We have hence warrant for the conclusion that simple determination is not caused by exaltation of the natural powers of the arterial structures.

325. On the other hand, direct observation, as well as reason, point out that determination of blood is caused by *enlargement of the arteries;* this enlargement is the effect of increased pressure acting from behind on a tube which has lost some of its contractile power (§ 120). The tonicity of the arteries makes them naturally resist the distending influence of the mass of blood pumped into them by the heart; but when this tonicity is impaired in any artery, the contractile power of the branch or branches nearer to the heart still goes on forcing blood into it; it however, being weakened, yields to this force, instead of resisting in turn and pushing on the blood, and so gets dilated, and becomes an enlarged channel for the transmission of more blood and more force to the vessels further on (§ 323). Hence when an artery is thus enlarged, the capillaries and veins

to which it leads also get dilated, and share the increase of blood and motion (§ 298, *note*). The proof of the enlargement and distension of arteries running to an inflamed or irritated part is offered in the increased and harder pulse felt in them; the coats of the vessels being so much more stretched, and at the same time rendered less elastic, the pulse is no longer softened by the usual spring.

When the web of a frog's foot is gently irritated by an aromatic water, the arteries may be seen through the microscope to become enlarged, and to supply a fuller and more impulsive flow of blood to the capillaries and veins, which then all become enlarged too; the whole vascular plexus, including vessels which before scarcely admitted red corpuscles, then becomes the seat of a largely increased current. This is determination of blood.

326. As these phenomena have not been distinctly described by observers, apart from the effects of *over*-irritation, which leads to *obstruction* and *inflammation*, I will state shortly the results of many observations I have been able to make, on the influence of moderate stimuli applied to the web of the frog's foot. These observations were made in the summer of 1841, and some of them are mentioned in my Gulstonian Lectures, published in the Medical Gazette of July, 1841.

The arteries may be distinguished from the veins in the web of the frog's foot, not only by the direction of their current and its greater rapidity and transparency, but also by the presence of a series of lines running along their course; these lines mark the size to which they have been distended at some previous time. (See A, fig. 1.) These linear channellings are most distinct, and they are also more remote from the artery at its angles or bifurcations. They are to be seen at some points along the veins, but much less plainly. Now these lines are in themselves proofs of the varying distension of the arteries, and they also furnish the means of measuring the amount of the variation.

When a weak infusion of capsicum is applied by a camel's-hair pencil to the web, there is a momentary retardation of the current in the veins, and the artery distinctly shrinks in size. But in a few seconds the reverse takes place; the artery swells to beyond its former size, and reaches the outmost line of its channel; the flow of blood through it becomes too rapid to be distinguished, and all the capillaries present a scene of busy motion: in some the particles pass in numbers and speed greater than the eye can

follow; in others that were before invisible, single files may be noticed forcing their way in more deliberate, but continuous

Fig. 1.

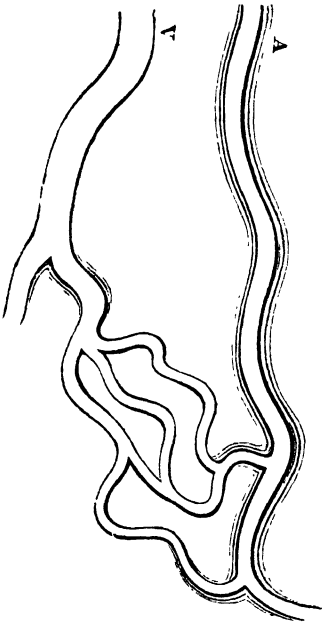
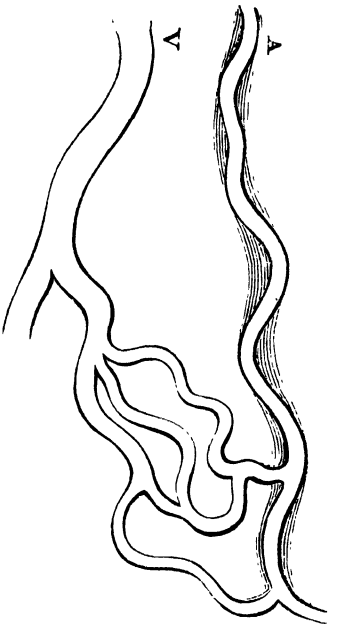


Fig. 2.



motion; in the veins the movement is again more rapid. This motion however soon begins to flag, and becomes remittent or oscillatory in some capillaries; and it may then be seen that the arteries have already begun to shrink in size, and the channelled lines, which had been effaced, to re-appear. Sometimes, in shrinking, the artery assumes for a time a more tortuous shape than before, (as A, in fig. 2;) so that its walls cease to be parallel with the outlying lines; this seems to show that the vessel contracts in diameter before its length is proportionally reduced. The contraction of the artery, and consequent reduction of the quantity and movement of the blood in the vascular plexus, was promoted by repeated applications of cold water (§ 124), which in some instances stopped the motion of the blood altogether, by diminishing the artery to so small a size, that no blood corpuscles entered it. A weak solution of acetate of lead produced this effect in a more decided degree.

The determination of blood excited by the means described above produces an increased redness that is quite perceptible to the naked eye; but it is less intense and of lighter hue than the redness of inflammation or congestion.

Several years subsequently to my experiments, Mr. Paget observed that the small arteries of the web of a frog's foot contract after being slightly irritated by the scratching of the point of a needle over them, and presently afterwards enlarge to beyond their original size (Lectures on Inflammation, Med. Gaz., June, 1850). Mr. Wharton Jones noticed that a great enlargement with increased current, preceded by little or no constriction, followed the application of wine, of spirit, of opium, of a strong solution of salt, and of a weak solution of sulphate of copper. A strong solution of sulphate of copper, on the other hand, produced dilatation of the vessels, followed slowly by permanent constriction (Prize Essay on Inflammation, Guy's Hospital Reports, 1850).

It has been objected that I assume enlargement of vessels to be the cause both of increased motion (in determination) and diminished motion (in congestion), which seems contradictory; but if my opponents fully consider all my explanation of these conditions, they will cease to hold that there is contradiction anywhere. In determination the vessels enlarged are the arteries, which being near to the source of motion and highly charged with its propulsive power, give vent to the stream as a reservoir under high pressure would: whereas in atonic congestion the vessels enlarged are the veins and capillaries, which are remote from the source of motion, and receive their impulse only through the arteries, which are not enlarged, and they may be even contracted (§ 294); thus the accumulated blood becomes comparatively stagnant. There is nothing contradictory in these applications of simple hydraulic principles: they are indeed further illustrated by the fact, that those parts are most liable to determination of blood which are nearest to the source of power; thus the head, face, and neck, present this phenomenon much more frequently than the structures of the lower extremities.

327. There appears, then, to be no difficulty in tracing local determination of blood to an efficient physical cause, enlargement of the arteries leading to the affected part; and if it is not equally easy to give a physiological explanation of the cause of this enlargement, it is only because the intimate nature of the tonic contracti-

lity of arteries has not yet been sufficiently studied. The terms "active dilatation" (Hunter) and "vital turgescence" (Kaltenbrunner) have been applied to the condition in question; but all that is known of animal physics is opposed to the possibility of there being a power of active dilatation in the arteries. It is quite true that in many instances of determination of blood, the exciting cause seems to operate directly, in stimulating the functions of the cells or tissues in connexion with the capillaries, rather than to be expended immediately on the arteries; but the arterial enlargement must follow before there is determination of blood; and assuredly there are cases of determination of blood where there is no previous capillary excitement.

The essential physiological cause of the arterial enlargement seems to be a weakening or reduction of the tone (§ 123) of the vessel, so that it becomes passively distended by the normal vis a tergo sent from the heart. In some cases, it might be supposed that this weakness was the result of exhaustion from stimulation (§ 116); and it has been stated above that a momentary contraction of the artery does precede its dilatation. But the amount of dilatation is out of all proportion to the previous contraction; and, in some cases, as in blushing, in the results that follow the application of heat, and in the natural growth of parts, there is no sign of any previous contraction having occurred.

328. Dr. Billing ingeniously conceives that, by stimulating the nerves, the nervous influence is drawn away from the vessels; and that their contractility, derived from this influence, is thus impaired. There can be little doubt that the nerves—especially the sympathetic (§ 152)—are sometimes concerned in causing determination of blood; and it is not improbable that they do so by reducing the contractility of particular arteries, just as strong moral emotions, acting through the nerves, paralyse the sphincters and muscles of voluntary motion (§ 144, 154). Valentin and others have observed distinct contraction of the aorta on irritating the sympathetic nerve or the roots of the cervical nerves. Probably this contraction is followed by enlargement and consequent determination of blood. The recent experiments of M. Bernard clearly bear on this point. He found that division of the sympathetic nerve in the neck of the rabbit was immediately followed by enlargement of the bloodvessels of the eye and ear of the same side, with throbbing, and increase of sensibility and temperature,—symptoms, in fact, of determination of blood; and this condition continued for several days (Gaz.

Médicale, Jan., 1854). The injury to the sympathetic seems, therefore, to impair the tonicity of the vessels, and thus to cause their dilatation with increased current of blood through them. Mr. Wharton Jones has also found dilatation of the arteries and increased current of blood through the leg of a frog, after section of the ischiatic nerve when it had connexion only with the sympathetic system. But the intimate nature of tonicity, the laws which it obeys, and its relation to the nervous influence, still require further investigation.

329. We can readily understand the *final* cause or purpose of determination of blood. "Ubi stimulus, ibi fluxus." The increased flow is intended to preserve the well-being and to support the function of the part. If any accidental influence threaten its well-being or excite its function, more blood is wanted: the arteries therefore dilate, to supply more, and to allow it to arrive with greater force, and so the circulation through the part is augmented. The result is, if in moderation, to increase the redness, warmth, sensibility, secretion, nutrition, and other functions; and if in excess, to disorder and alter them.

330. We have hitherto considered local determination of blood as resulting from causes which directly affect that part of the vascular system in which the determination takes place. In not a few cases, however, the same result arises from causes acting on distant parts of the vascular system. Thus external cold causes internal congestions by intropulsion (§ 292), and so too it may occasion internal determinations of blood. By constricting the vessels of the surface and extremities, it directs the force, as well as the chief quantity of the circulating fluid on internal parts that are beyond its constringing influence. Thus in many persons, cold applied to the surface and extremities, causes palpitation, dyspnœa, pain in the chest, throbbing, pain and heat in the head, gastralgia, colic, and fluxes of various kinds. It is obvious that in such cases the force of the heart is expended chiefly on the arteries of the internal organs, which thence become dilated, and are the seat of determination of blood; whilst those of the surface and extremities are contracted and bloodless. The commencement of reaction from the cold stage of a fever is commonly marked by determination of blood to the head and other parts in like intimate relation with the centre of the circulation, which hence get excited, and suffer more or less pain and disorder.

The subjects in whom cold causes internal determinations of

blood, are chiefly those who are endowed with much irritability of heart (§ 113), and who have but little blood (§ 261). The same persons likewise are liable to a flush of blood to the face and head, and to coldness of the feet, when they go into a warm room. By heating the head, the feet are made cold; if, on the other hand, the feet are warmed, the head is cooled.

331. Attacks of local determination of blood induced by other causes are often accompanied by shivering fits, pallidity of the surface, coldness of the extremities, and defective secretions, particularly in persons of weak circulation. When an unusual quantity and force of blood are determined to one part, there must be less of both in other parts, which therefore suffer from the deficient supply. This connects itself with an important therapeutic principle, to be noticed hereafter.

332. As we find determination of blood to be chiefly produced by an enlargement of some arteries, in consequence of a reduction of their tonicity (§ 325), we may be led to expect that such enlargement may affect any part of the arterial system. We have chiefly hitherto considered determination in relation to the distribution of blood to parts; but it may also occur in the great arterial trunks. Inordinate pulsation of the aorta, especially in the abdomen, at the cœliac axis, or at the bifurcation into the iliacs, (corresponding with a position a little below the epigastrium and at the umbilicus,) is a common symptom in nervous subjects, and may perhaps be accounted for by the observations of Valentin and Bernard, before quoted (§ 328). I have frequently observed epigastric pulsation to occur before and after hæmatemesis. In several cases I have noticed the occurrence of nephralgia, hæmaturia, and lithic deposits in the urine, in patients affected with strong pulsation at the umbilicus.

SYMPTOMS AND EFFECTS OF DETERMINATION OF BLOOD.

333. Many of the symptoms of determination of blood may be inferred from the preceding illustrations. It generally causes a flush of heat in the part, and exalts the contractility (§ 112), sensibility (§ 126), and other nervous properties (§ 149), sometimes exciting spasm, pain, irritation, and sympathetic disorder. In its moderate degrees, it increases the natural secretions of the part (§ 162), and thus becomes the cause of mucous, bilious, and urinary fluxes, &c. The nutritive function is a slow process,

and is only affected by determination of blood when this is constant, or often repeated; then it is exalted in consequence, and more naturally than from congestion, the result being a simple and general hypertrophy of the part. Thus the arteries which are the channels of determination, and are at first only dilated, eventually become thicker in their own coats, and present in all respects larger dimensions. The process of absorption, although favoured when the blood-current is accelerated without distension of the vessels, is nevertheless not equal to the task of removing the results of effusion caused. Hence determination of blood may cause dropsy in sacs and cavities.

A few special examples will suffice to illustrate the symptoms and effects of local determination of blood.

334. The parts most subject to determination of blood are those nearest to the heart in the distribution of their vessels, and those most freely supplied with blood (§ 30), as for instance the brain, the parenchyma of glands, the mucous membranes, and the skin.

335. Determination of blood *to the head* takes place in some persons in consequence of mental excitement, violent exertion, the use of stimulant drinks, or from defective excretion. The symptoms vary considerably; but increased beating of the carotid and temporal arteries, some flushing of the face and suffusion of the eyes, and an increase of the symptoms on stooping, or lying with the head low, are present in all cases. The other symptoms are sometimes those of simple excitement of the nervous centres, painful throbbing in the head, excessive sensibility to light and sound, flashes in the eyes, noises in the ears, an excited state of the mind, a rapid flow of ideas, sometimes bordering on delirium, wakefulness or dreamy sleep, restlessness and irritability of temper. Sometimes they are those that indicate a temporary oppression of the nervous functions, such as giddiness, drowsiness, stupor, imperfect vision and hearing, specks or mist appearing in the eyes, impaired articulation and powers of locomotion, and occasionally various convulsive affections, such as are present in hysteria and epilepsy. It has been before mentioned that fits of these disorders are not unfrequently produced by determination of blood to the head (§ 153).

336. It may seem difficult to explain how such opposite symptoms as those of excitement and those of oppression, are produced by one and the same cause — determination of blood. But the explanation is really simple if the true nature of determination, and

the different modes in which it affects the circulation within the head, are borne in mind. Moderate excitement of the brain, such as is induced by bodily exercise, mental exertion, or taking certain beverages, like tea and coffee, is accompanied by increased, but equal, flow of blood through the organ. But when these or other causes of excitement operate more energetically, the arteries supplying the brain are greatly dilated, and convey blood to it with more force, but without there being an equal increase in the quantity that passes *through* it; and this for two reasons. 1. As we have already seen, a certain degree of size and elasticity in the vessels best qualifies them to transmit blood freely (§ 301); where this is wanting, increased force does not compensate for it, but only causes new disorder. Thus in violent palpitation of the heart, the aorta, carotid, and subclavian arteries are often dilated, and throb strongly; and so much force is then expended on these larger trunks, that very little reaches their distant branches, as is proved by the weak pulse at the wrist. In the same way, in determination of blood to the head, the chief force is very apt to be expended in the larger vessels at the base of the brain, instead of being transmitted throughout its substance. 2. Another reason for the unequal or deficient excitement in determination of blood to the head, is the unyielding nature of the skull, which permits no great enlargement of some of the vessels within it, without a corresponding diminution of other vessels, and a general compression of the cerebral substance. Distension of the arteries, beyond a certain degree, compresses and obstructs the small veins, and thus prevents that freedom of circulation on which functional activity depends. Thus then is explained the production of symptoms of depressed, as well as of excited, energy of the nervous centres, besides occasionally a mixture of both, by one and the same cause, determination of blood (§ 153).

337. Determination of blood *to the kidneys* is produced by the use of stimulating diuretic drinks, and besides the increased flow of urine, may lead to pain in the loins and throbbing in the abdominal aorta; and the urine discharged may present an increase not only of its water, but also of its acid ingredient, as well as of epithelial cells thrown off from the uriniferous tubes, and in case of intense determination of blood, such as that caused by the use of the most stimulating diuretics, such as turpentine, serum and even blood may be mingled with the urine. Dr. G. Robinson has produced artificial albuminuria in animals, by tying one of the

common iliac arteries, whereby more blood was thrown upon the kidneys. Excitement of the circulation, by exercise or by nervous affections, also affects the kidneys; exercise necessarily causes the escape of much fluid from the skin; but nervous excitement, when it fails to cause perspiration, determines powerfully to the kidneys; and this probably is the explanation of the abundant flow of limpid urine which follows attacks of convulsive and other nervous affections. External cold operates in a similar manner; by constricting the superficial and extreme vessels, it directs the blood in unusual quantity and force on internal organs, especially the kidneys; and so produces enuresis.

338. Determination of blood *to mucous membranes* is exemplified in certain forms of dyspepsia, in which sudden pain, heat, or nausea, is felt in the stomach, accompanied by epigastric pulsation, and sometimes followed by the eructation of sour or other kinds of liquid, and sometimes by hæmatemesis. These attacks are often induced by excitement, general or local, following the use of irritant ingesta, and the application of external cold. A similar affection of the intestines causes a diarrhœa; and of the air tubes, a bronchial flux; it is a common character of these affections that they are suddenly produced under the influence of various exciting agents.

339. Determination of blood *to the skin* often results, not only from direct irritation, but also from the influence of internal causes; as seen, for instance, in blushing from mental emotion, in flushing of the face from the presence of acid in the stomach, and in the general redness of the surface upon reaction after exposure to cold, or at the commencement of fevers. In various chronic skin-diseases the effect of determination is marked in a brightening of the colour of the eruption; this sometimes takes place within a few seconds.

340. Determinations of blood are commonly transient, coming on suddenly and soon subsiding. When they are more enduring, they often lead to other disorders. In their immediate seat they cause either increased secretion, with the addition to the secreted matters of more or less of the watery, saline, and albuminous parts of the blood,—or hæmorrhage,—or they may even pass into inflammation. In other parts of the body, remote from the seat of determination, there is often, at first, coldness, defective circulation and impaired function (§ 330), but afterwards a febrile reaction sets in, with hot skin, accelerated pulse, scanty secretions, and other symptoms of inflammatory fever.

341. The frequent recurrence of determination of blood, or its long continuance in a slight degree, affects the structure in which it occurs; increased nutrition,—hypertrophy,—being the result. This may be a natural kind of hypertrophy, like that which happens to muscles that augment in size in proportion to their exercise, and the consequent circulation of blood through them. The uniform hypertrophy of the substance of the heart, and of other organs, after long-continued excitement of the organ, may be referred to the increased determination of blood that has been kept up. In other cases parenchymatous tissues, such as those that form the substance of the kidneys and liver, exhibit alterations rather than mere growth; albuminous deposits are formed, and granular degeneration results. In these and other instances the effect on the structure is generally modified by the presence of congestion, or inflammation, and by the plastic condition of the blood itself (§ 211).

It is unnecessary to dwell longer on the phenomena and results of determination of blood, because we shall have to revert to them in speaking of the occasional consequences of the condition—flux and hæmorrhage,—and of inflammation, of which it is a component part.

REMEDIES FOR DETERMINATION OF BLOOD.

342. In the treatment of all cases of determination of blood, as in that of diseases in general, it is obviously proper to attempt to remove the exciting cause, whatever that may be. Thus in the numerous class of cases which arise from the direct action of stimuli or irritants on the part which is the seat of the determination (§ 323), the withdrawal of such irritants, or the diminution of their operation by the employment of soothing or diluent remedies, is a first indication.

343. If we are correct in tracing local determinations of blood chiefly to an atonic distension of the arteries supplying the part (§ 325), we may expect measures which promote the contraction of those vessels to prove efficient remedies. This is confirmed by experience; the application of cold is one of the most effectual means we possess for subduing determinations of blood; and this has been mentioned as an important remedy for defective tone (§ 124). Astringent applications are equally useful in some in-

stances of local determination; as seen in the use of solutions of acetate of lead, of sulphates of zinc and copper, of nitrate of silver, and of other constringing lotions as external applications (§ 326), but these are chiefly effective when the determination is quite local and unconnected with generally increased circulation: under other circumstances they become irritants rather than astringents (§ 317). According to the observations of Mr. Wharton Jones, a solution of sulphate of atropia and other preparations of belladonna, promote the contraction of dilated arteries; and from their general therapeutic characters it is not improbable that arnica and tobacco possess a similar power, and might be used as antagonists to the morbid condition under consideration. The signal relief sometimes afforded by both these drugs, to inflammatory and painful irritations of the mouth, teeth, fauces, and skin, seems to prove that they exercise some control over determination of blood, as well as over nervous sensibility.

344. Besides the employment of cold and other astringents as applications to the part which is the seat of the determination, and to the arteries leading to it, *derivants*, or means which draw away blood therefrom by relaxing other portions of the vascular system, are especially pointed to by many preceding observations (§ 330, 331, 340). Of these derivants, heat is the most effectual, especially when combined with moisture. Thus cold lotions or the cold douche applied direct to the head, and the employment of the hot footbath at the same time, constitute together the best treatment for determination to the head. Taking copious draughts of cold water, or more sparingly of iced water, will often relieve epigastric pulsation and palpitation of the heart. The use of the warm bath, by deriving to the surface, diminishes the flow of blood to the kidneys. I have known a severe attack of nephralgia instantly relieved by cold affusion on the loins; but the practice has too much hazard in it to be recommended.

345. Various evacuant remedies may also be employed to counteract determination of blood, for these too determine a flow in another direction; purgative diuretics and diaphoretics, thus often prove useful. Of these, purgatives are by far the most powerful and sure in their operation, and they are of great efficacy in determinations to the head. Change of posture may sometimes be made useful by elevating the part which is the seat of determination.

346. But the most powerful derivant of all is bloodletting, general or local. The microscope may be made to show how opening a bloodvessel changes the course of blood; the currents in many vessels are reversed and drawn towards the bleeding point, whilst in others they are retarded where they were before running with great speed. But bloodletting is unnecessary, and even injurious, in many cases of determination of blood, especially such as are attended with a deficiency of blood in the whole system; and, as has been seen, such cases are not rare (§ 330). Dry cupping is a good substitute in some such instances; but even this measure is more weakening than it is generally supposed to be, for by it much blood is extravasated into the skin and cellular texture, and is so really lost to the system as blood: its corpuscles being changed, and their structure destroyed.

The cases in which bloodletting proves most beneficial are those where determination to an important organ is combined with some general plethora or local congestion, or where it has continued so long as to threaten to terminate in inflammation. A *speedy* blood-drawing, either by cupping or free venesection, will generally answer its purpose best.

347. In the same class of cases, certain remedies are useful which seem to cause a general relaxation of the tonic fibres (§ 122) of the vascular system, and also an equalization of the force and quantity of blood which this system conveys (§ 331). Antimony is the most powerful of these remedies; and its use is most indicated where febrile reaction has begun.

348. Another class of remedies suitable for employment in determination of blood, attended by much excitement, are sedatives, or such as reduce the heart's action (§ 115); digitalis, aconite, hydrocyanic acid, and nitre, are of this nature. These are chiefly useful when the determination occurs in connexion with palpitation, as happens in the various convulsive or other sudden nervous attacks which I have shown to be so commonly excited by palpitation (§ 322). I have entirely cured several cases of convulsive hysteria, and have much reduced the frequency of the fits in epilepsy, by using these remedies, sometimes combined with cold affusion to the head in the morning, and with the hot footbath at night (§ 331). Hydrocyanic acid probably operates chiefly on the organic excito-motory nerves, and, by lowering their function, prevents the undue excitement which they communicate to the heart.

In this respect it surpasses conium and hyoscyamus, which are also sometimes useful in preventing determination of blood arising from nervous excitement.

349. We have found (§ 330) that in many instances determination of blood to internal organs results from weakness of the circulation, and especially from a want of tone in the whole vascular system (§ 123); so that when cold constricts the external vessels, or irritations excite the internal organs, these latter monopolize most of the blood and force of the heart's action. In such cases, besides temporary measures that tend to equalize the circulation, (as for instance the application of heat to the extremities and surface, of cold and astringents to internal organs, the employment of gentle exercise, friction, &c.,) more permanent influences are to be sought in tonics, and various particulars of diet and regimen, which act by giving strength to the contractile fibres (§ 124), and by improving the quantity and quality of the blood (§ 271).

Thus preparations of iron and bark are useful remedies in the cases of greatest weakness: the mineral acids, iodide and bromide of potassium, mild bitters, and the lighter metallic tonics, nitrate of silver, sulphates of zinc and copper, and liquor arsenicalis, prove serviceable in others which do not bear the stronger tonics well. In using any of these remedies it is necessary to guard against their exciting effects on the parts which are the seats of determination, by premising, or adding the temporary remedies (§ 342, &c.) suited to this morbid condition, and by keeping the secretions free and equally balanced.

In all cases, country air, exercise adapted to the strength of the patient, and habits of posture that are opposed to the peculiar determination, will be found serviceable to promote the removal and to prevent the recurrence of this kind of disorder.

SECTION VI.

RESULTS OF

350. Before proceeding to the consideration of the third and more complex variety of local hyperæmia—inflammation—we must just glance at some remarkable results to which congestion and determination lead, when rendered intense to a certain degree, but

stopping short of the conditions present in that third variety—I mean, *hæmorrhage, flux, and dropsy*. These results have been already mentioned as sometimes ensuing from plethora, congestion, and determination of blood; and therefore in now recurring to them, it will be unnecessary to do more than exemplify their occurrence in connexion with these proximate elements, and trace the further peculiarities which distinguish each of these results.

I. HÆMORRHAGE.

351. The bloodvessels may, in any form of hyperæmia, be distended to so great a degree, that their coats give way, and blood is then effused. I shall proceed to give illustrations of the more common cases of hæmorrhage resulting from the several kinds of hyperæmia which have been already described.

General plethora (§ 275) not unfrequently causes hæmorrhage, from the nose (*epistaxis*), from the stomach (*hæmatemesis*, vomiting of blood), from the rectum (*hæmorrhois*), and into or upon the brain (*apoplexy*). The operation in each of these cases, except the last, is more likely to be advantageous than otherwise, because it reduces the excessive fulness of the bloodvessels; but it may be attended by unpleasant consequences and require control.

352. Congestion from *venous obstruction* (§ 289) may produce hæmorrhage in various situations. In this way *pulmonary apoplexy* (hæmorrhage into the parenchyma of the lungs) follows upon obstructive disease of the left side of the heart: bronchial hæmorrhage and *hæmoptysis* (spitting of blood) upon tubercles in the lungs; hæmatemesis and bleeding piles upon obstructions of the liver and bowels occasioned by disease or violent straining.

353. Congestion from *weakness of the vessels* (§ 290) often leads to hæmorrhage in dependent parts, and in various textures during certain kinds of fever, and in debilitated subjects. Most passive hæmorrhages are of this nature. A stooping posture has been known to cause cerebral hæmorrhage (apoplexy). An erect one occasionally brings on uterine hæmorrhage (§ 291).

354. The congestion of the head that follows the intropulsive operation of cold (§ 292) sometimes issues in epistaxis and apoplexy; that which results from previous excitement of the stomach and kidneys in drunkards (§ 294), occasionally causes hæmatemesis and *hæmaturia* (bloody urine). The congestion of

the kidneys incidental to scarlatina and the cold stage of ague, is sometimes followed by hæmaturia.

355. Hæmorrhage, from determination of blood (§ 322), is exemplified in such cases of epistaxis and apoplexy as are preceded by increased beating of the carotids, flushing of the face, &c. (§ 335); in hæmatemesis induced by the action of irritants on the stomach (§ 338); in hæmaturia brought on by stimulant diuretics (§ 337); and in the bloody dysentery that sometimes follows the use of drastic purgatives, &c. (§ 323). So also we shall find hæmorrhage to be a common concomitant or result of inflammation.

356. But the cases of general or local hyperæmia noticed above, do not of necessity result in hæmorrhage: some essential element may be wanting; and this element may be either in the *blood-vessels* or in the *blood.*

357. The bloodvessels are sometimes obviously in a diseased state. When the arteries of the brain are inelastic and fragile, from osseous or fatty degeneration, or from aneurismal dilatation, they are very apt to become ruptured under the influence of congestion or determination of blood. When they are softened by inflammation or malnutrition, the bloodvessels of various structures readily give way: hæmorrhage occurs on this account from an inflamed stomach or colon, in tuberculated lungs, in a softened brain, and in a diseased uterus. Occasionally actual ulceration or suppuration opens an artery or vein; this is by no means an uncommon cause of hæmorrhage in chronic ulceration, in suppuration of lymphatic glands or tonsils, and in malignant disease of the stomach, intestines, and uterus. Mechanical injury may rupture bloodvessels in the kidneys and nostrils; hence hæmaturia and epistaxis sometimes follow violent blows in the loins or on the nose. I have repeatedly known hæmatemesis to ensue upon the act of lifting a heavy body from a height, a proceeding which with peculiar force compresses the liver.

358. But in other instances the hæmorrhagic disposition can be traced to a peculiar state of the blood. Sometimes it is defective in fibrin (§ 196), but abounding in red corpuscles (§ 184), as in petechial fevers, congestive apoplexy, hæmorrhagic small-pox, and other exanthemata. But there are other cases in which the disposition to hæmorrhage prevails without any defect of fibrin or excess of red corpuscles; scurvy and purpura are examples of these. In scurvy indeed there is excess of fibrin and deficiency

of red corpuscles (§ 185, 196).* It appears probable that a alteration in the *quality* of the red corpuscles (§ 186) and fibr (§ 203) is at the bottom of the evil in these diseases. The read ness with which textures become stained by the colouring matte the purple, brownish, or particoloured blotches left by inflamma tion, and, in extreme cases, the altered appearance of the bloo itself, all seem to prove that the colouring matter of the blood i diseased; the failure of the healing process, and the remarkably loose and blood-stained appearance of fibrinous coagula whicl form on the spongy gums, or in wounds, indicate that the fibrir is deficient in contractility and vital plasticity (§ 211). Some microscopic observations have been alluded to (§ 203, 187), as bearing upon this subject; but more are needed for the completion of the inquiry.

359. Another very important question connected with hæmorrhage relates to the mode in which the blood gets effused. In some cases the bloodvessels are distinctly ruptured (§ 357). But in other instances blood has been poured out in considerable quantities from mucous surfaces, and even from the skin, without any discernible breach of vessels, or even of the surface. This has been observed particularly in epistaxis, in hæmatemesis, and in some remarkable cases of hæmorrhage from the skin, occurring successively at different parts of the body. Considering the size of the red corpuscles of the blood, and the absence of any visible pores in the walls of the bloodvessels, even when examined by the highest magnifying powers, it does not appear possible that those little bodies can escape from the vessels without rupture either of their own walls or of the vessels. At the same time, it must be remembered that in the web of the frog's foot the red corpuscles are observed to pass through capillaries of calibre smaller than their short diameter: I have myself often seen them rolled up in the manner of a confectioner's ice wafer when so passing. J. Hewson noticed the flexible and extensible property of the red corpuscles, and his observation has been confirmed by his commentator, Mr. Gulliver. The appearances presented in capillary apoplexy (cerebral hæmorrhage), and hæmorrhagic inflammations of serous membranes, countenance the opinion that

* In acute hæmorrhagic purpura the fibrin is not deficient, for I have found that the blood effused beneath the skin is firmly coagulated. I have before alluded to my experience that purpura is generally connected with imperfect action of the liver (§ 171).

many minute vessels become ruptured at once, probably in connexion with an altered condition of the blood: such minute ruptures occurring in membranes might not be discernible by common modes of examination. All cases of this description that have lately come under my notice have included as an element, an altered state of the blood (§ 358), generally of the nature of uræmia (171, 249) or cholæmia (§ 250). Rokitansky and De Lange have noticed that in numerous cases of hæmorrhages that came under their observation the bloodvessels were unusually delicate and vulnerable, and the blood at the same time abnormally thin. Mr. Paget has proved the existence of fatty degeneration of the small arteries of the brain in case of cerebral hæmorrhage.

VARIETIES OF HÆMORRHAGE.

360. Besides the differences in their seat, hæmorrhages are distinguishable into *active* or *sthenic*, and *passive* or *asthenic;* and the peculiarities of these distinct varieties may be traced to the same structural causes as the corresponding varieties of general and local hyperæmia, namely (§ 279), excess or deficiency of the contractile power of the heart (§ 110), and of the tonicity of the arteries (§ 120). Thus hæmorrhages preceded or accompanied by the symptoms of sthenic plethora (§ 280), or by determination of blood (§ 322), are *active* or *sthenic;* whilst those occurring in connexion with asthenic plethora (§ 281), or with mere congestion (§ 287), are *passive* or *asthenic*. The symptoms already described, when treating of these subjects, are therefore the precursory symptoms of each kind of hæmorrhage.

361. But so soon as the hæmorrhage begins, its occurrence may modify the previous symptoms in various ways, besides producing new ones locally through the discharge of blood. In active hæmorrhage, the full, hard pulse of sthenic plethora acquires a remarkable jerk or thrill. This is very important when loss of blood is suspected, but cannot be seen. I have noticed this characteristic thrill in the pulse even when the loss of blood has been very trifling, and when no murmur has accompanied the heart's sounds; and I am therefore inclined to think that it depends on an unusual abruptness of the heart's contraction (§ 113), combined with some irregularity in the tonicity of arteries in different

parts (§ 326, 332), which causes these to react in successive jerks at each pulse, instead of simultaneously. In fact, this same thrill is sometimes felt during a paroxysm of determination of blood to a part when no hæmorrhage accompanies it.

If the quantity of blood effused be large, and especially if its loss be rapid, actual syncope, or various slighter degrees of faintness and weakness, may ensue. The pulse too becomes small, weak, and often irregular, and the surface and lips pale; either consciousness, or the heart's action, may be the first to fail, according to the posture of the patient at the time (§ 70), and the condition of anæmia (§ 262) is induced.

362. Even after this faint state has been produced, increased action (reaction) will return in the course of a few hours; and it is in this that the pulse exhibits the greatest degree of the jarring or vibratory character; so that it may feel like a loose wire twanging, or a rough file drawn, under the finger. With this state of the pulse, palpitation, throbbing of the great arteries, and the various symptoms of local nervous excitement described under the head of anæmia, are very apt to occur (§ 266). During this reaction the hæmorrhage may be renewed.

363. If the hæmorrhage is inconsiderable, or if it be suddenly checked by styptics before the vascular fulness or determination has been reduced, inflammation may ensue, accompanied by increasing strength and hardness of the pulse, heat of skin, and other symptoms of inflammatory fever. On the other hand, hæmorrhage, if it be considerable, may remove the hyperæmia, and relieve the sense of fulness, tightness, and pain, the functional derangements and the other local and general symptoms of oppression, which it had produced. Thus headache and flushing are often relieved by epistaxis; cough, pain, and oppression in the chest by hæmoptysis; abdominal pain and pulsation by hæmatemesis, melæna, or hæmorrhoidal flux.

364. But the blood effused may produce various disturbances in the parts into which it is poured. When the hæmorrhage is within the head it of necessity causes pressure on the brain; and by interrupting the circulation through it, it may induce coma or paralysis (§ 273); or it may at once break up the cerebral substance, and so cause death by syncope (§ 116) and asphyxia combined. When it is in the lungs, the blood may at once suffocate by its quantity, or it may cause dyspnœa and cough until it is

expectorated. Here, too, it sometimes mechanically breaks up the texture of the organ and leads to serious disorganization. When it is in glands it forms swellings, or is mixed with, and modifies, the secreted matters, as seen in the case of hæmaturia. Hæmorrhage into other complex textures produces swelling, not uncommonly followed by local inflammation; this is instanced in the cutaneous blotches of purpura hæmorrhagica.

365. Passive or asthenic hæmorrhage may be preceded by symptoms of asthenic plethora (§ 281) or congestion, and may be accompanied by symptoms of exhaustion if the loss be profuse, or of relief if it be moderate; anæmia may ensue from excessive loss; reaction, sthenic hæmorrhage, or inflammation, may be the result if the bleeding be too suddenly checked. The hæmorrhage connected with an altered state of the blood is generally of the passive kind, although excitement, or determination of blood (*molimen hæmorrhagicum*), sometimes occurs here also.

TREATMENT OF HÆMORRHAGE.

366. As hæmorrhage is commonly a result of plethora, congestion, or determination of blood, the remedies for those morbid elements will be as commonly more or less needed in its treatment. But the demand for their use will very much depend on the extent and seat of the hæmorrhage, and the mischief likely to result from its continuance. For example: a moderate epistaxis or hæmorrhoidal flux needs no treatment; it is a natural cure for a previously existing hyperæmia. But if either of these be profuse, they must be restrained, and equally so whether they be of the sthenic or asthenic kind: if sthenic, by artificial bleeding, and by derivation to other parts, both of which measures reduce the fulness which causes the hæmorrhage: if asthenic, by the use of styptics, combined with derivant measures, in order that the loss of blood, which is injuring the system, may be stayed.

367. In some cases, however, hæmorrhage to even the slightest amount may be injurious, and therefore must be opposed from the first, both by remedies for the hyperæmia, which is the cause of the hæmorrhage (§ 345, *et seq.*), and by styptics, which peculiarly counteract this result. Hæmorrhage into the lungs, the brain, or any other internal vital organ, requires prompt interference. So also does excessive hæmorrhage of any kind under all circumstances,

and more moderate loss in very weak subjects. In all of these cases the continued flow of blood may be attended by urgent danger.

368. In *active* hæmorrhage, bloodletting may generally be persevered in until the flow is arrested, or the pulse reduced; and the effect should then be sustained by the influence of other evacuants, especially purgatives and diuretics. Remedies which diminish the power of the heart, such as digitalis, hydrocyanic acid, and nitre, and those which also reduce the tonicity of the arteries, especially preparations of antimony, are likewise of great use in some forms of active hæmorrhage. Another powerful agent for the arrest of hæmorrhage, connected with increased action or determination of blood, is cold (§ 343). Thus ice, or a stream of cold water applied to the nose and forehead is of great efficacy in epistaxis; ice taken into the stomach, in hæmatemesis; ice employed externally, or the injection of ice-cold water, in uterine hæmorrhage (§ 344). I do not however approve of the practice recommended by some, of applying ice to the walls of the chest during hæmoptysis; I have known pneumonia thus induced, and the resulting consolidation is apt to run into rapid consumption. Cold water is sometimes very effectual in arresting the flow of blood from a wound; Dr. O. Rees has suggested that in this case in addition to its direct constringent operation on the vessels, it may possess the power of arresting the capillary circulation in consequence of the red corpuscles being made to swell up by the influence of osmose.

The treatment of *passive* or *asthenic* hæmorrhage, besides the employment of styptics to prevent excessive loss of blood, includes also the use of remedies for general plethora (§ 286), or local congestion (313, &c.) which may be the cause of the hæmorrhage. Hence general or local depletion, and derivant medicines, accompanied or followed by tonics, are commonly useful.

369. We have now to consider the means that are calculated to restrain all kinds of hæmorrhage, but which are more especially adapted to arrest the flow when it has been caused through disordered circulation (§ 356). If the bloodvessels are softened, brittle, or actually ruptured or ulcerated (§ 357), the chief thing to be done is the diminution of the quantity of blood sent to them; and, besides the employment of bloodletting, this may be effected by pressure, regulation of the posture, cold and astringent applications, and the use of measures calculated to tranquillize the whole circulation. Thus epistaxis is sometimes arrested by pressure on the

carotids; uterine hæmorrhage by pressure on the abdominal aorta, or by elevating the pelvis; hæmoptysis by keeping the chest high. In all cases of hæmorrhage, perfect stillness and a cool regimen are indispensable.

370. The other pathological condition which inclines to hæmorrhage,—an altered state of the blood (§ 358),—is perhaps more directly influenced by the administration of remedies called styptics. Most of these remedies are astringents, and act by causing contraction of the tonic fibres of vessels and other parts, but some of them also render the blood more plastic and coagulable, and then exercise a twofold influence over the mischief.

Of those medicinal agents which cause both contraction of the vessels and increased coagulability of the blood, the most powerful are acetate of lead, alum, sulphate of copper, chloride of zinc, and nitric and sulphuric acids. Other styptics, as for instance nitrate of silver, sulphate of zinc, sulphate of iron, and infusion of nutgalls, are certainly astringent, but they have also been generally supposed also to coagulate the blood; Mr. Blake's experiments however show that they have not this latter effect when injected into the veins of living animals (see *note* to § 214). When applied topically, they coagulate the blood in the bleeding vessels. Nitrate of silver acts in this way upon leech-bites; so also does the actual cautery. But this influence cannot be exerted upon the blood in the channels of the circulation, or it would produce the most dire results. There, no doubt, the coagulating power is restrained by some antagonistic forces; but it is allowed to come into play as the astringents pass out of the blood through the terminal capillary vessels, or other channels.

In some cases of hæmorrhage, the styptic remedies may be applied directly to the bleeding part, as in epistaxis, hæmatemesis, hæmorrhoids, and uterine hæmorrhage. In epistaxis, solutions of alum, acetate of lead, and sulphate of zinc, are sometimes injected into the nostrils, or applied by sponge or lint. In hæmatemesis, sugar of lead, alum, gallic acid, creosote, oil of turpentine in small doses, and the mineral acids, may be given by the mouth, so that they operate directly on the bleeding part. In excessive hæmorrhoidal flux, enemata, containing some of the same remedies, are immediately beneficial. Oil of turpentine scarcely ever fails to stop the bleeding which in some cases continues into the socket after the extraction of a tooth.

371. In many instances, the bleeding part is beyond the reach of the direct application of styptic remedies; yet some of them may be made to exercise considerable power in restraining the hæmorrhage through internal administration. Thus hæmoptysis is assuredly sometimes checked by frequently repeated doses of sugar of lead (which should be combined with a little opium or conium, to prevent its griping the bowels); and more uncertainly by ipecacuanha, gallic acid, alum, and other astringents. Hæmaturia of the passive kind is diminished by small doses of oil of turpentine; passive uterine hæmorrhage by gallic acid, ergot of rye, and tincture of the sesquichloride of iron. Opium given internally has been found effectual in some cases of uterine hæmorrhage. It is difficult to explain how it operates; but it is probably through the same astringent property that enables it to diminish many of the secretions. It is a remarkable fact that all astringent medicines that exercise a restraining effect over hæmorrhage, as well as other excessive flows, possess the power of precipitating albumen from solution. Every one of the mineral astringents does this. And so also do turpentine, creosote, and tannic acid. It is highly probable that astringents cause contraction of muscular fibres, and act on the tonicity of tissues through this chemical influence over albumen, and that so their constringing and coagulating powers are but modifications of the same force. When these coagulating agents are administered as internal remedies, they act immediately on the mucous membranes with which they come in contact, before entering the blood. Then in the blood their coagulant influence is kept in abeyance, but it comes into play again as they issue from it, and so produces its peculiar effects on the structures through which they are thrown out. Hence when astringents are to be successfully employed as internal remedies they must be in such quantity, that even after dilution in the general mass of the blood, they may be still capable of exerting a decided influence upon the organs or parts for which they are designed. Hence in a general way those medicines are most extensively applicable that are comparatively harmless in themselves when introduced into the blood; alum, the salts of iron and tannic and gallic acid are of this nature. In cases of hæmorrhage the preparations of iron are especially pointed out as likely to be of great service, where there is time to secure their results, because they tend to hasten the reproduction of the red corpuscles, at the

same time that they constringe the parts that are the outlets of the flow. These preparations are also of further value on account of the readiness with which they can be combined with sulphuric and hydrochloric acid, as in the muriated tincture, and in acid sulphate of iron. Creasote is a powerful astringent, but it can hardly be given in sufficient internal doses to produce an effect on a remote part of the system, because it has powerful influences as a neurotic; it however is very efficient in restraining hæmorrhage from the part to which it can be applied, namely, the mucous membrane of the stomach. Sulphuric acid acts principally upon the mucous membranes, but while in the blood, it is certainly combined with alkalies into neutral salts that are not astringent, hence when it acts upon any part as an astringent, after having been in the blood, it does so because that part has the power of resolving the neutral salt and separating it again. Most of the vegetable astringents owe their properties to tannic or gallic acids; of these two compounds tannic acid has proved itself to be the most powerful agent when used externally, and gallic acid when administered through the blood. And yet tannic acid is now known to be merely gallic acid plus something else. M. Braconnot has shown that tannic acid is merely gallic acid combined with the elements of grape sugar ($C^{12} O^{12} H^{12}$). Six atoms of gallic acid and one molecule of grape sugar make three atoms of tannic acid. M. Pelletier has successfully solved the enigma of the gallic acid, *which does not coagulate albumen by itself,* being nevertheless so valuable an agent when administered through the blood. He has shown that a mixture of gallic acid and of solution of gum coagulates liquid albumen, although neither of the two can do so alone (see Turner's *Chemistry,* 7th ed., p. 995). But gum is chemically identical with grape sugar, or very nearly so; and grape sugar is always present in the blood. Gallic acid of necessity becomes tannic acid when mingled with the blood, and then becomes chemically coagulant or astringent. It has on the other hand very little power when externally applied, because it then does not find the material necessary for its conversion into tannic acid. Tannic acid already prepared may be employed externally, and for the alimentary and genital passages. The astringent property of gallic acid may be directed on a particular secreting organ by combining it with an agent which acts on the secretions of that organ. Thus in hæmaturia it should be conjoined with a diuretic,

and the bitartrate of potass which is not stimulating, is very fit for this purpose. It is probable that uva ursi, buchu, and pareira, owe their efficacy in diseases of the urinary organs to a similar combination of an astringent with a diuretic action.

372. In some kinds of hæmorrhage, as in intestinal fluxes, remedies which increase the proper secretions of the canal and of its glandular allies, such for instance as mercurial and saline purgatives, prove to be the most effectual, particularly if combined with others of a styptic kind, like sulphuric and nitric acids, alum, and sulphate of zinc. This mode of treatment is often sufficient for the cure of slight hæmorrhages, or for obviating dispositions to hæmorrhage from the lungs and uterus, or from the textures affected in purpura hæmorrhagica; and it doubtless acts through its influence on the condition of the blood, as well as by its evacuant and styptic powers.

II. FLUX AND DROPSY.

373. Another result of the various kinds of hyperæmia, is an effusion of the watery part of the blood holding more or less animal and saline matter in solution. This result, occurring in secreting organs or from open surfaces, constitutes *fluxes*; in closed sacs or in the cellular connective texture, it constitutes *dropsies*. There is so much that is common in the pathology of fluxes and dropsies, that a great deal of repetition may be avoided by speaking of the two together in the first place; and then afterwards their distinguishing peculiarities may be advantageously noticed apart.

374. General plethora sometimes leads to flux or dropsy; but these results most commonly ensue where the bloodvessels are temporarily distended with blood containing an undue proportion of water. Thus, if water be gradually injected into the veins of a living animal, the circulation and breathing become embarrassed; and after a time dropsical effusions take place into the abdomen, the chest, and the connective tissue; or a flux occurs from the kidneys, intestines, or skin; or several of these results happen together; and the bloodvessels so get relieved of their distension. The same effects have sometimes been produced by excessive drinking, especially when the kidneys and the skin, the natural emunctories for superfluous fluid, have at the same time failed to perform

their usual office. Thus drinking largely of a cold liquid when the body is perspiring and fatigued, is very apt to weaken the heart's action, and to check the cutaneous and renal secretion; the bloodvessels then become filled to distension, and not uncommonly relieve themselves by dropsical effusions or diarrhœa. Cold externally applied sometimes operates in precisely the same way; it first arrests perspiration, and causes internal congestions (§ 292); and if, from previous over-excitement or other disorder, the kidneys are unequal to take upon themselves extra work to compensate for the skin's default, general fulness is the result, which tends to find issue in some dropsy or flux. The sudden suppression of a cutaneous eruption, or of the discharge from an old ulcer, has sometimes been followed by anasarca, diarrhœa, or bronchial flux (humid asthma). The colliquative sweats of advanced phthisis are of the nature of a flux; the bloodvessels, in their obstructed and weakened state, thus relieve themselves of superfluous liquid. These sweats may generally be stopped by a judicious restriction of liquid ingesta and an avoidance of too warm clothing.

375. Instances of local congestion terminating in flux and dropsical effusion are afforded in almost every variety of this condition that has been already enumerated (§ 288, *et seq.*). In fact, such is the most common cause of partial dropsies.

The adequacy of venous obstruction to produce dropsy was well illustrated in some experiments of Lower. He had tied the jugular veins of a dog, in the expectation that the animal would die of apoplexy; instead of this result, however, its face and head became swelled with considerable œdema. He then tied the ascending vena cava; and ascites and anasarca of the lower extremities were the consequences. Disease affords numerous examples of dropsy and flux being produced by venous obstruction. Aneurisms of the arch of the aorta, or other tumours, that press on the venæ innominatæ, or descending vena cava, sometimes cause œdema of the face and upper extremities. In a case (which was under my own care) of malignant tumour involving the roots of the lungs, there were hydrothorax, and flux into the bronchial tubes (bronchorrhœa). In advanced pregnancy and ovarian dropsy, the legs commonly swell in consequence of the pressure of the tumour on the iliac veins. Many instances are recorded in which the occlusion of a large vein was followed by dropsy of the part from which the vein proceeded. The ascending vena cava has been found

obliterated in persons who had long been affected with ascites and anasarca of the lower extremities. In the University College collection, there is a drawing of such a case, in which a supplementary circulation had been established by means of an enormous enlargement of the superficial veins of the abdomen. Dr. Watson relates an instance of the same kind.* M. Tonnele has made some observations which favour the notion that chronic hydrocephalus may be caused by a partial obliteration of the venous sinuses of the head (§ 267). Mr. Gulliver informs me that he has in many instances traced extensive œdema of the lower extremities to obstructions by clots, mostly fibrinous, in the iliac, femoral, or popliteal veins.†

But the most common causes of venous obstruction are certain visceral diseases, and these are commonly attended by either dropsy or flux. Contractile disease of the liver, cirrhosis, is the most frequent of all causes of simple ascites; and diarrhœa and gastrorrhœa (watery eructations) are very apt to occur in connexion with various functional and structural diseases of the liver. Structural disease of the heart, especially if seriously affecting the orifices or valves, commonly leads to hydrothorax, bronchial flux, (humid asthma), and sometimes even general dropsy. Pulmonary congestion, induced by circumstances that impede the respiration (§ 298), such as spasmodic asthma, emphysema, laryngitis, hanging, and coma, sometimes results in a bronchorrhœa or hydrothorax. In the experiments of Dr. J. Reid, a serous flux into the bronchial tubes ensued after the division of the par vagum; this was a consequence of the impaired respiratory action, inducing pulmonary congestion.‡

376. As congestion arises from weakness of the circulation and atony of the vessels (§ 290), so dropsical effusions and fluxes proceed from the same causes. Thus œdema of the lower extremities is a common sign of extreme weakness; as seen after severe illness, and towards the fatal termination of many chronic diseases. Colliquative diarrhœa and perspiration (fluxes) sometimes occur under similar circumstances. The œdema and fluxes which arise from weakness are more readily induced by postures which cause gravitative congestion in the affected parts. Thus continued

* Library of Medicine, Art. "Dropsy," vol. v.
† Med. Chir. Trans., 1839.
‡ Edin. Med. and Surg. Jour., vols. 49, 51.

standing causes swelling of the legs, and leucorrhœa, in persons liable to these affections.

377. Fluxes and dropsical effusions sometimes occur after previous excessive excitement of the vessels of a part. Hence œdema after erysipelas, and the infiltration of serum into cavities and textures after great activity of the vessels of these parts, even when no inflammation has been present. The gleets or fluxes which follow inflammations of the urethra, bronchi, alimentary canal, and vagina, seem to be connected with precisely the same condition of the vessels that sometimes causes congestion (§ 294). Persons who indulge in spirituous liquors often suffer in the morning from waterbrash, and find a glass of spirits the best remedy for it: in this case, however, obstruction in the liver (§ 56, 371) may have to do with the result.

378. Fluxes sometimes arise from the intropulsive operation of cold (§ 77, 292); diarrhœa and catarrhal affections, too transient to be inflammatory, are frequently thus induced; ordinary diuresis (flux of urine) is an example of the same influence, although in this case an operation of undisturbed health. It is doubtful whether cold suffices in this way to cause dropsy; but it may increase it where it existed previously.

379. The other variety of local hyperæmia, determination of blood (§ 321), also produces fluxes and dropsies. The influence of various stimulants on secreting organs and surfaces illustrates this (§ 324). Thus snuff taken into the nose determines a flow of nasal mucus and of tears; spices in the mouth provoke a discharge from the salivary glands; the inhalation of irritating vapours causes a flux in the air-tubes; purgative medicines induce a flux from the intestines, &c. In these cases, the irritation is short of inflammation, a state which, although attended with determination of blood and effusion, also comprises other conditions. The fluid thus secreted in fluxes from determination of blood, differs from the products of inflammation: it commonly consists of the natural secretion of the part diluted with an unusual proportion of water, and loaded with saline matter derived from the blood; the excess of saline matter sometimes gives to the secretion an irritating quality, as instanced in the discharge of coryza, bronchorrhœa, and watery diarrhœa.

Other examples of flux may be referred to determination of blood unconnected with special irritation; such is the leucorrhœa

which precedes and follows the menstrual period, the bronchorrhœa or gastrorrhœa excited in some cases by increased action of the heart, and the sweat succeeding to flushes of blood to the head or other parts.

380. Dropsy is not so commonly a result of simple determination of blood; because, independently of inflammatory action, there are comparatively few circumstances that can throw increased flow of blood upon closed sacs. But probably the dropsy that accompanies tubercular deposits in the peritoneum and membranes of the brain may be partly induced by the mechanical irritation of the tubercles causing a flow of blood to the membranes. The sudden manner in which tuberculous hydrocephalus sometimes makes its attack seems to countenance this opinion; for this affection is unquestionably attended by the phenomena of determination of blood to the head, already described (§ 323). The kinds of dropsy called inflammatory may be included under the same head; but we shall shortly see that the determination of blood, or excitement of the circulation, present in such cases, is itself consequent on an altered condition of the blood.

381. As flux and dropsy commonly arise from similar conditions of the vascular system, so they are sometimes found to succeed one another. Thus Andral mentions a case in which hydro-thorax was removed on the occurrence of a profuse flux from the air passages. Examples are not uncommon of the subsidence of ascites on the occurrence of diarrhœa, or of the supervention of ascites when a diarrhœa of long duration has been suddenly checked. Dr. Watson quotes from Dr. Farre's lectures an instance in which hydrocele was removed by violent purging. It is a familiar fact that the occurrence of dropsy is commonly attended by a marked diminution of the urinary secrētion, and that a return of its free flow is often connected with a reduction of the dropsical effusion. A knowledge of these several facts points out the most effectual treatment for dropsy.

382. It has been stated that flux, dropsy, and hæmorrhage, are occasional results of the different varieties of hyperæmia. But what are the circumstances which determine the precise nature of the result in any case? We have seen that the additional or determining cause of hæmorrhage is either in the vessels or in the blood (§ 350). So also similar conditions may incline to the occurrence of flux and dropsy. An extreme amount of vascular

distension pretty certainly results either in rupture and hæmorrhage, or in the exudation of the watery parts of the blood (§ 305, 340); the long continuance of congestion or plethora too, by making exhalation predominate over absorption, rarely fails to lead to like consequences. But both dropsical effusions and fluxes sometimes take place with a facility that is disproportioned to either the amount or duration of hyperæmia; in these cases the cause may be traced to a generally lax, flabby state of the tonic and contractile fibre (§ 123), to a poor, watery state of the blood (§ 222), or to both these conditions acting together. Persons liable to these affections are usually of pale complexion and phlegmatic temperament (§ 40).

The influence which relaxation of the solids has in producing profluvial and hydropic disorders, is exhibited in their occurrence in organs after over-excitement (§ 294), when there is no indication of general disease of the blood. But in cases in which the blood is diseased, there is usually also a relaxed state of the vascular fibre; and it is not then easy to distinguish the exact influence of each of these causes in the production of the result. The liability to dropsy and fluxes which is present after long fevers, defective nourishment (§ 63, 196), or confinement in impure air, must be attributed to the joint operation of both classes of causes indicated above.

383. The conditions of blood which predispose to watery effusions require further consideration. A poor or watery state of the blood, is the most obvious of these: and that this alone is sufficient for the effect is plain, from the fact already noticed, that injecting water in considerable quantity into the veins of a living animal, will cause effusions or discharges; the injection of blood or serum in the same way does not lead to the same result. Persons who have lost much blood are liable to become dropsical, because the bulk of the lost blood is replaced by watery serum absorbed from various sources, which thus renders the mass of the liquid more dilute (§ 264), and because the solid constituents of the blood are removed much more rapidly under such circumstances than the water (§ 192). Watery blood tends to produce dropsy and flux, not merely because thin fluids have greater proneness to transude through the walls of the vessels, but also on account of the failure and irregular distribution of the force of the circulation. It has been already explained, under the head of

anæmia (§ 262), that a scantiness of blood embarrasses the circulation. The structure of the heart and its valves, and of the vessels, is adapted to act upon a certain spissitude and quantity of the blood; and when these vary much from the natural standard,—when the blood instead of being of an unctuous fluidity, is watery and *squashy*,—the hydraulic moving apparatus is less capable of effecting its propulsion: it has been experimentally ascertained that liquids with a certain amount of thickness, run in narrow channels more freely than thinner ones, or pure water. A thin condition of the blood may thus by diminishing onward flow, not only facilitate watery effusions, but also promote the congestions and other derangements in the circulation with which flux and dropsy are commonly connected.

384. Several of the circumstances which induce a thin state of the blood have been already stated (§ 222, 249, 382), but in relation to dropsy, it is of more importance to consider what proves to be a more frequent cause, namely imperfect excretion by the kidneys, liver, and skin. In various forms of hyperæmia which lead to dropsy and flux, (plethora, congestion and determination of blood,) it will be generally observed that these results ensue in proportion as the excreting organs fail, and that the removal of the dropsy or flux is most certainly ensured by the employment of measures which restore, or compensate for the defective excretion. Exposure to cold is very commonly followed by dropsy; and at first sight this might seem to operate merely by checking perspiration, and thus retaining in the vessels water that should be eliminated, and which is then effused within the body. But checked perspiration alone will not cause dropsy: there must be a failure at the same time in the action of the kidneys, before this result will ensue. If these perform their office properly, checked perspiration may disorder the circulation, and cause congestions, inflammations, and even fluxes; but I have never met with a case of dropsy arising from exposure to cold, in which there was not a deranged condition of urine; in the great majority of instances, it was albuminous.

The circumstances in which exposure to cold is most liable to induce dropsy, are such as also tend to impair the action of the kidneys at the same time. A man in a fit of intoxication lies for several hours of the night on the cold damp grass; he arises much chilled, has shivering succeeded by fever, and general dropsy soon

after ensues: the urine is very scanty, and on examination is found to be highly albuminous. Here the vital powers of the kidneys had been exhausted by the excitement of the stimulant beverage, so that when cold checked the perspiration and threw the blood on internal organs, these in particular could not take upon themselves their vicarious and compensatory office; and so their vessels became distended with blood, and mechanically exuded serum, instead of separating the proper constituents of urine (§ 309); these and the superfluous water accumulate in the blood, and alike by their undue quantity and irritating qualities, cause effusions of serum with urea in different parts of the body, as well as producing other functional disorders before noticed (§ 170). In all cases of this nature, the danger is strictly in proportion to the evidence of renal derangement and disorganisation. It is much greater when the urine discharged is alkaline, phosphatic, and highly albuminous, than when it is still acid and depositing lithates with epithelial scales, and even blood corpuscles in addition to the albumen. In this latter case there is much more chance that the disordered organ may yet right itself.

Another instance of a similar kind of general dropsy is that which supervenes after scarlatina. This has been ascribed by some to a sub-inflammation of the cellular tissue, originating in the eruption; by others to the diseased state of the skin, which is left by the eruption, suppressing the perspiration. But if either of these were the true cause, the dropsy ought to occur most in the cases in which the eruption is most abundant; this however is by no means the fact; nay I have had occasion to treat several patients in whom anasarca has followed a scarlatina fever, with sore throat, in which there was no rash at all. In all these cases the urine was albuminous, and this again shows that the diseased action of the kidney is the most essential lesion connected with general dropsy. How scarlatina impairs the function of the kidney is a question too extensive to be discussed here; but I will simply state my belief that it does so by causing a highly congested state in these glands, which injures their secreting power (§ 304), much as happens with regard to the liver in bilious and intermittent fevers. A female who was under my care with albuminuria, which was almost cured, was attacked with mild scarlet fever: the urine, which had been merely hazy under the influence of heat and nitric acid, immediately became highly coagulable, and con-

tinued so until the fever declined, when the albumen again gradually decreased.

It has been remarked by several observers that in the early stages of albuminuria, whether after scarlatina or from other disorders causing great congestion of the kidneys, the urine also contains an abundance of the epithelial cells of the uriniferous tubes, either detached or agglutinated together in the shape of casts of the tubes. This desquamation of the uriniferous epithelium for the time impairs its secreting power; hence the urine is diminished, whilst the congested Malpighian bodies still pour out water, containing more or less albumen, and in some cases even red corpuscles. The disposition to this escape of blood corpuscles is favoured by their altered and partly broken condition (§ 187), which is also a cause of petechiæ and other hæmorrhages in scarlatina. In cases where the vitality and nutrition of the organ are unimpaired, the uriniferous tubes soon become furnished with a new and active epithelium, and the secreting power is restored, whilst the removal of the congestion causes the disappearance of albumen from the urine. But under the opposite condition of low vital power and mal-nutrition, the epithelium may not be renewed; the proper secreting power of the tubes is not recovered, and they continue to let pass the mere watery exudation of the Malpighian bodies, with more or less albuminous impregnation according to the fulness of the bloodvessels. Thus in cases of confirmed albuminuria many of the uriniferous ducts have been found without any epithelium. Besides these changes, fibrinous deposits and fatty degenerations occasionally ensue in the kidney, which it is not necessary to particularize further in this place.

The general dropsical state which occurs towards the fatal termination of structural disease of the heart, I have in several cases found to be connected with albuminuria and slight jaundice, and I have been long in the habit of pointing out these as the most surely fatal complications to which heart diseases naturally tend; their connexion has been before noticed (§ 305, 309).

385. The pathological effects of the secretion of serous and scanty urine (oliguria) have been already described (§ 170, 249), but we must more particularly advert to the mode in which it induces dropsy and flux. When dropsy results from a suddenly operating cause, such as exposure to cold, or scarlatina, a febrile state is generally present, with a frequent and hard or sharp pulse,

heat of skin, thirst, &c. These symptoms, occurring in connexion with the anasarca, have led to the use of the terms inflammatory, febrile, acute, or active dropsy; and so far as these are taken as merely implying the presence of an excited state of the vascular system, they cannot be objected to. But they are sometimes employed to express the cause of the dropsy, as if this were the immediate consequence of the excitement or inflammatory condition. That such a condition is often present, is obvious not only from the febrile symptoms, but also from the buffy state of the blood when drawn from a vein, and from the dropsical effusions and fluxes being in many cases combined with both the symptoms and the products of inflammation. Thus anasarca is often attended with great tenderness, and sometimes with an erysipelatous redness: swellings of the joints frequently have the character of rheumatic inflammation; effusion in the abdomen and pleura is commonly accompanied by pain or tenderness, and after death slight deposits of lymph are found in addition to the serum; catarrhal flux from the bronchi, and diarrhœa, are associated with more irritation (spasm, constriction, and cough, or vomiting, pain, and soreness) than occurs with simple fluxes.

But this inflammatory character may be readily explained by referring it to the irritating quality of the excrementitious matter which the imperfect action of the kidneys leaves in the blood. In this form of dropsy, urea has been found in the blood and in various effusions (§ 170), and may therefore be fairly regarded as a *materies morbi*, carrying irritation to various parts, and setting up excitement and sundry effusions or discharges, as the system seeks to relieve itself from its offensive presence. In two points this condition resembles acute rheumatism (§ 351);—1. in the number of distinct organs which may be simultaneously or successively affected; 2. in the want of any constancy in the seat of the affections. Both these circumstances indicate that the essential cause is not in the disordered part, but in the blood. Another peculiarity which approximates these morbid states to gout and rheumatism, is the nature of the excrementitious matter which accumulates in the blood. There is good evidence that lithic and lactic acids are the chief abnormal ingredients that are present in gout and rheumatism (§ 256); but I have so commonly found also an excess of urea in the urine of patients recovering from rheumatism, and the most effectual remedies for gout and rheu-

matism so distinctly increase the elimination of this principle (§ 257), that we can scarcely doubt that in these affections urea also is either produced in excess, or is insufficiently excreted. The proximity in composition between lithic acid and urea, and the probable conversion of the former into the latter (Liebig), should be borne in mind while considering this subject. Both gout and rheumatism, as well as oliguria, frequently produce fluxes or catarrhal affections. Indeed the periodic recurrence of catarrh in certain individuals bears a strong resemblance to the analogous visitations of gout; and they are sometimes vicarious in the same subjects. Lastly the relation of these affections to imperfect purification of the blood, is further illustrated by the facts, that rheumatism is frequently complicated with albuminuria (as after scarlatina); and that granular degeneration of the kidneys (Bright's disease) is apt to supervene in the most aggravated forms of rheumatism.

386. But besides the retention of excrementitious matter in the blood, there is also in these cases *a loss of albumen* from this fluid. That this loss facilitates dropsical and profluvial effusions, by thinning the blood (§ 383), is most probable in all instances; but it seems to be the especial cause of the same results in the more chronic forms of disorder, and in the most anæmic subjects; for here (as it has been already stated (§ 264), the blood is thinner and more watery than it is in any other disease. Thus in advanced stages of granular degeneration of the kidneys, and even in earlier stages if the subjects are anæmic, almost every congestion or determination of blood ends in watery effusion. As the powers of the circulation fail, gravitative congestion chiefly determines the situation of the effusion, and hence it mostly occurs in the lower extremities, and the œdema presents in a marked degree the property of pitting on pressure, and very readily draining through any punctures made in the skin; in this respect differing from the dropsy of acute albuminuria, in which the swelling also affects the face, the trunk, and the upper extremities, the pitting not being always distinct. The former dropsy is well entitled to the appellation—asthenic or passive, both on account of its being connected with congestion and weakness of the circulation, and from the poor condition of the blood, and the consequent depressed or cachectic state of the vital functions dependent upon it (§ 262, 185).

387. From the preceding statements it will be inferred that acute dropsy arises chiefly from the retention in the blood of excrementitious matter and water which the kidneys fail to eliminate, and that the more chronic or asthenic kinds of the disorder, although often originating in the same way, are rather dependent on a poor or watery state of the blood, especially deficient in albumen (§ 222). This deficiency in many cases arises, both from the continued drain by serum in the urine and from the imperfect assimilation and nutrition connected with the state. But there is sufficient evidence that the more chronic and asthenic forms of dropsy do sometimes arise from this impoverished state of the blood, independently of disease of the kidneys. Thus Andral and Delafond found dropsy to occur in anæmic sheep in connexion with distomata in the liver, only when the albumen of the blood was below the natural standard. The dropsy induced in the human subject by very scanty or poor food, by close confinement in unhealthy places, or by residence in malarious districts, and that supervening in extreme states of debility or cachexia, are probably dependent, not merely on weak or obstructed circulation, but also on an impoverished condition of the blood itself. For the same reason, the various structural diseases which cause congestions, especially those of the heart and liver, often do not induce dropsy until the quality of the blood is impaired through imperfect excretion and inadequate nutrition.

388. We have thus traced the origin of flux and dropsy in common, to states that have been previously considered by themselves,—hyperæmia in some of its forms, and a diseased condition of the blood (§ 222), dependent on defective excretion (§ 249, 250), or defective nutrition or assimilation (§ 268). The latter element, although not essential to the production of fluxes or local dropsies, is the main cause of general dropsy, and is at the bottom of what is called the dropsical diathesis. If beyond this we endeavour to distinguish between the pathological causes of flux and dropsy, observation will teach us that flux more commonly results from determination of blood or congestion, with a lax state of the solids (§ 123, 382), and that dropsy is associated rather with the altered condition of the blood.

389. The distinction thus made between the causes of flux and dropsy implies that flux is generally a more local affection than dropsy, for many circumstances relax the vessels of a part without

affecting the condition of the blood in the whole system. This is especially apt to happen to secreting organs and surfaces, and hence these are the common seat of fluxes. Excessive secretion has been already noticed as a primary element of disease (§ 162), but the fluxes now under consideration consist less in excess of the natural secretion (although this often occurs also), than in the addition to it of a watery, saline, and sometimes albuminous fluid derived from the blood, a serosity in fact (§ 305, 375). The fluids discharged in chronic coryza, bronchorrhœa, gastrorrhœa, and watery diarrhœa, consist of the natural mucus of the respective surfaces, much diluted with a thin serum, the saline matter of which often gives to the secretion an irritating property. Sometimes this serous fluid is completely substituted for the proper secretion, as in the coagulable urine of the more advanced stages of Bright's disease.

The circumstances which most commonly induce flux in secreting surfaces have been enumerated (§ 376, *et seq.*), but after a flux has continued for some time, it is apt to become habitual, apparently in consequence of the permanent relaxation of the affected vessels. These become so weak that any circumstance which disorders the circulation brings on an attack of the flux. In fact, the flux becomes an habitual outlet for superfluous fluid thrown into the bloodvessels, and the ordinary escape for discharges which ought to be evacuated through the kidneys, skin, or bowels.

GENERAL TREATMENT OF FLUX AND DROPSY.

390. As there is so much that is common to fluxes and dropsies, our notice of remedial measures may be advantageously arranged by first alluding to the treatment that is equally applicable to both, and by afterwards specifying that which is more particularly suited to each.

In so far as fluxes and dropsies depend on plethora, sthenic or asthenic, on congestion in any of its varieties, or on determination of blood, the remedies for these several morbid states (§ 283, *et seq.*, 313, *et seq.*, 342, *et seq.*) must form part of the treatment. So, also, as according to the prevalence of these constituent conditions, fluxes or dropsies may be more or less sthenic and active, or asthenic and passive, and more or less constitutional or local, the treatment must be varied correspondingly. And again,

as these conditions are tractable or not, the fluxes and dropsies resulting from them may be easy or difficult to remove, and may exhibit great variations in regard to duration and disposition to return. Thus fluxes and dropsies which arise from congestions caused by structural disease of the heart or liver, or by the pressure of tumours upon veins (§ 375), although often removed for a time, are very likely to return; whereas those that arise from cold (§ 378), weakness (§ 376), previous excitement (§ 377), or functional disorder, may, in many cases, be permanently cured.

391. We have repeatedly stated the circumstances under which vascular congestion or fulness in itself suffices to induce dropsy and flux (§ 306, 383); and under these circumstances the remedies for congestion and plethora are obviously of the first importance. Thus in dropsy or fluxes suddenly induced by structural disease of the heart and liver, often after exposure to cold, over-exertion or excitement, the condition of the blood has not materially suffered, and hence depletion, general or local, may then sometimes be advantageously premised before adopting any other measures. Afterwards such other treatment should be employed as serves to reduce the remaining congestion and the effusions resulting from them, by the administration of remedies that increase the secretions; combinations of mercury, or antimony, with squill and digitalis, are peculiarly adapted to accomplish this object. Various other means contribute to the same end, in particular all such influences as are of an evacuant and derivative nature. Treatment of this kind approaches to the antiphlogistic, for we have already seen that the character and products of congestion of high tension, and of sthenic plethora, approximate to those of inflammation (§ 307). In the more special causes of flux and dropsy however,—those that induce these results with slighter amounts of congestion or disordered circulation (§ 382)—those which constitute the dropsical and profluvial diathesis (§ 388)—we find conditions betokening general weakness, and requiring a tonic and more supporting plan of treatment; namely, a relaxed state of the solids, and a watery condition of the blood. But even in the management of these cases, it is sound practice to attempt to derive from the weak or congested parts, and to increase defective excretions. Further details on these matters will be better arranged under the separate heads that follow.

TREATMENT OF FLUXES.

392. In all cases of flux, it is right to derive from the affected part, and to promote the natural excretions in other directions, by the employment of some or other of the following means: warm bathing, warm clothing, exercise, friction and stimulant applications to the surface, the administration of diaphoretic, diuretic, and aperient medicines. It is also necessary that circumstances which promote congestion or determination of blood in the affected part, such as a dependent position, exposure to heat, the application of cold elsewhere, too fluid a diet, &c., should be avoided. In addition to these measures, it may be requisite to use others that counteract or remove the irritations or obstructions which the flux itself causes. Demulcent and narcotic remedies are sometimes useful in this way in catarrh and diarrhœa, soothing the irritation caused by the secreted fluid; at other times, expectorants and purgatives are serviceable by promoting its expulsion.

393. The further treatment of fluxes should be guided by the vascular state accordingly as it is sthenic or asthenic. Flux, like hæmorrhage, is sometimes attended by a hard, frequent pulse, heat of skin, and other signs of fever or of sthenic plethora: then evacuants, antimonials, sedatives, and even bloodletting, are the remedial measures that are required. In fact, the disordered state borders on inflammation, and needs a similar treatment. Some cases of flux of a sthenic character depend upon the presence of gouty or rheumatic matter in the blood: here colchicum and alkalies are the proper remedies, because they promote the removal of this matter through the kidneys. Others, as we have seen, are connected with albuminuria (§ 380), and are to be treated accordingly. In all these examples of sthenic or active flux, it is neither useful nor safe to attempt hastily to check the discharge by astringent remedies, lest the determination of blood that is present should end in a worse result, hæmorrhage or inflammation.

394. The majority of fluxes are, however, asthenic, and connected with a weak state of the vessels, local or general, and other plans must be adopted. Besides the general measures above alluded to (§ 392), it is here safe and proper to endeavour to check the profuse exhalation, by astringents, stimulants, and general tonics. Astringent remedies are most effectual when

directly applied; and the mode in which they then act, namely, by constricting the relaxed vessels (§ 388), is obvious. Thus acetate of lead, sulphate and acetate of zinc, sulphate of copper, nitrate of silver, alum, and the vegetable astringents containing tannic acid, are effectual in restraining leucorrhœa and diarrhœa. Some of these remedies seem also to act through the medium of the circulation. Thus sugar of lead, sulphate and oxide of zinc, sulphate of copper, and mineral acids given internally, sometimes distinctly diminish bronchial flux and profuse perspiration, as we have already seen that they arrest hæmorrhage (§ 367). Some fluxes are remarkably checked by medicines whose operation seems to be rather stimulant than astringent. Thus spices, essential oils, and brandy, sometimes cure pyrosis and diarrhœa; cantharides diminish leucorrhœa; cubebs and copaiba put an end to gonorrhœa; balsams of copaiba and Peru occasionally check bronchorrhœa. It is uncertain how these remedies operate; but as stimulants they most probably act by removing congestions, through causing determination of blood which excites contraction and improved tone of the capillaries of the part (§ 317): hence they are certainly most successful in asthenic cases originating from inflammation. But many of them have a powerful diuretic operation, on which much of their efficacy may depend: and some seem to exert a peculiar influence on the secreting powers of mucous membranes. Another medicine occasionally useful in controlling fluxes, is opium; its mode of action is not obvious; but is probably connected with its power to diminish natural secretions (§ 166). Its efficacy is most apparent in diarrhœa and diuresis: but it is sometimes beneficially combined with metallic astringents in the treatment of bronchial and gastric fluxes.

The state of the system in persons subject to fluxes is generally one of relaxation, and is therefore benefited by tonic medicines. Such of these as have also an astringent property, are peculiarly adapted to prove serviceable in asthenic fluxes. It is thus that the tincture of the sesquichloride of iron is useful in the treatment of leucorrhœa and humoral asthma, attended with much debility; infusion of cusparia, in that of diarrhœa; and bark or quinine with mineral acids, or gallic acid and tannin, in most of the profluvial disorders of very relaxed habits.

For the same reason the diet should be as generous as the digestive organs will bear; including the use of animal food twice

a-day, if practicable, and a moderate allowance of some sound fermented liquor. Excess in liquid food should be particularly avoided, especially large quantities of tea, and warm *slops* generally. I am in the constant habit of curing catarrhal colds, which are acute fluxes, simply by total abstinence from liquids during two or three days; and although this extent of *dry regimen* is obviously inapplicable to chronic cases, yet moderation in the use of liquids, especially before or during exposure to cold, is an important feature in the treatment even then. I have known several instances in which chronic coryza, bronchorrhœa, and diarrhœa were kept up, and possibly even brought on, by immoderate indulgence in drinking tea and other like beverages. These fluids cause a temporary fulness, which immediately finds a vent through the lax vessels of the weak part (§ 389). The favourable influence to be expected from warm clothing, regular exercise, and a bracing, but not too cold, atmosphere is obvious from the previous considerations.

TREATMENT OF DROPSY.

395. In addition to the use of means requisite for the removal of that variety of hyperæmia which induces the dropsy (§ 391), the attempt must also be made to remedy, as far as possible, those conditions of the blood which have been found (§ 384) specially to favour the occurrence of the disorder. The chief and most prevalent cause which determines these conditions is a failure in the secreting power of the kidneys: its sign being a scantiness of the urine, a deficiency of the natural constituents of the excretion, sometimes with an accession of albumen. The treatment of dropsy must therefore keep in view the condition of the kidneys, and the immediate cause of the failure in their action, and also the state of blood which is the result of that failure.

I have already several times pointed out (§ 309) reasons for supposing a highly congested state of the kidneys to be the first cause of that failure of their function which induces albuminuria and its consequences. The means that are found to be most successful in removing dropsy resulting from renal disease, correspond very well with this view. Thus in the acute or so-called inflammatory dropsy that occurs after scarlatina or exposure to cold (§ 384), bloodletting, especially by cupping the loins, hydragogue purgatives and diaphoretics, prove advantageous at first; and subsequently

some kinds of diuretic medicine, particularly tincture of cantharides, digitalis, and colchicum, tend to restore the natural action of the kidneys. Such measures, if resorted to at an early period, and before the disease in the kidneys has affected their structure, are often completely successful. They fulfil, not only the indication of diminishing the renal congestion, but that also of purifying the blood from excrementitious matter, and of reducing the sundry effusions, local irritations, and disturbances, which this matter excites in various parts (§ 385). They cure the dropsy by exciting artificial fluxes (§ 381).

Of the hydragogue purgatives used in the treatment of acute dropsy, I have found cream of tartar in large doses (ʒiv. to ʒx., every morning or every alternate morning), gamboge (gr. iv. to viii.), and extract of elaterium (¼ gr.), to be the most effectual. Tartarized antimony, alone or combined with opium, is the best diaphoretic, and it often relieves the catarrhal symptoms commonly present: but care must be taken that it do not cause vomiting, to which there is often a natural tendency. Dr. Osborne recommends the vapour bath, and Dr. Watson the hot-air bath, as measures likely to derive to the surface and to cause perspiration. After cupping to the loins has been repeated as often as the strength of the patient may allow, I have, in obstinate cases, seen much benefit follow the application of large blisters or other counter-irritants to the same part; and in asthenic cases, which do not bear the loss of blood at all, very large blisters (a foot square and upwards) may be used at first with great advantage; especially if followed by equally ample poultices. It is sometimes very remarkable how, on the rising of the blister, the urine increases in quantity, whilst its albumen diminishes; and at this time diuretics, especially salines, act more favourably.

Dropsical effusions are often soon dispersed by the preceding measures; but the proof of the permanent benefit of the treatment must be looked for in the progressive decrease of albumen, and the increase of urea and lithic acid in the urine. It sometimes happens that, after the full use of depletion, cathartics, and diaphoretics, the condition of the urine becomes stationary, and does not advance towards a healthy standard. Then the diuretics already named may be very effectual in augmenting the quantity of urine, without increasing the albumen which it contains; and where this is their first effect, steady perseverance in their use will often produce a

gradual diminution of the albumen. The tincture of cantharides is more powerful than all the rest in exciting the action of the kidneys; and where it increases the flow of urine, the dose may be augmented from ɱx. to ɱxx. or ʒss. thrice a-day; but if the smaller dose does not act as a diuretic, it is not safe to proceed to the larger, nor, in fact, to persist with the medicine; for it is then almost sure to irritate the kidneys, without increasing their secretion, and so to do harm. Certain saline diuretics, as the acetate and bicarbonate of potass, the benzoate of ammonia, and the iodide of potassium, either separately, or better in combination, sometimes succeed where the stimulating diuretic fails. A similar point has been alluded to in the treatment of congestion by stimulants (§ 317); if the remedies fail to remove the congestion, they aggravate the mischief. Digitalis and colchicum are safer diuretics than cantharides, inasmuch as they are less irritating to the kidneys; but they are also less powerful for good.

Mercury might be expected to be a useful agent in the removal of congestion or low inflammation from the kidney, and in the restoration of its secretion; but it salivates so speedily and severely in many cases, that it is not generally eligible, except in an occasional dose. The promptitude with which the gums are affected with mercury may be ascribed, partly to the facility with which inflammation is excited in any and every part (§ 385); and, in some measure, also to the failing action of the emunctories of the system, which permits the mineral to accumulate in the blood more speedily than usual (§ 260). As a practical rule, I have found that mercury is well borne, and is often useful, in those cases of albuminuria in which there is a deposit of urates or of free uric acid (which deposit denotes considerable secreting power in the organ), and that it is injurious and salivates quickly where the urine is pale and alkaline or neutral. Mercury is peculiarly efficacious in dropsy connected with diseased liver: and with squill, digitalis, and henbane, or conium, it forms a most useful diuretic combination in all recent cases of the disorders that are dependent on congestion, without actual disease of the kidneys being present. Here also the urine is highly loaded with lithates and colouring matter.

396. It has been stated (§ 386, 387) that the asthenic forms of dropsy, and those of the most chronic character, are commonly connected with a watery, non-albuminous state of the blood, and general weakness of the system. To obviate this condition, so

far as possible, by nourishing diet, tonics, and such management as increases the strength, becomes in such cases an important indication. When the disorder depends on mal-nutrition or mere debility (§ 387), this tonic and supporting treatment may be sufficient to effect a cure. In the more common examples of dropsy, rendered asthenic by the long continuance of structural disease of the kidneys, liver, or other organs, the same strengthening and invigorating measures must be more or less combined with the employment of agents calculated to excite the failing exernent organs, or to produce some compensating discharge. Thus in dropsy from chronic albuminuria, and advanced stages of granular degeneration of the kidney, the occasional exhibition of hydragogue purgatives and diaphoretics, and of the diuretics mentioned above, may prove advantageous, if bitters with iodide of potassium, or mineral acids, are given at the same time to keep up the general strength and powers of nutrition. In the more anæmic cases, iron is often of service; but it sometimes proves injurious by impairing the little secreting power remaining in the kidneys, and then rendering the urine more albuminous. Where it has this effect, its use must be abandoned. The preparations of iron that I have found most serviceable under appropriate circumstances are the ammonio-citrate combined with iodide of potassium, and the muriated tincture. Gallic and tannic acids have likewise been recommended under similar circumstances.

Asthenic dropsy arising from diseased liver is sometimes signally relieved by the combined influences of mercurial and diuretic medicines, followed by, or even conjoined with, the administration of calumbo, bark, and other vegetable tonics. In several cases I have succeeded in removing ascites, of great extent and long duration, connected with granular degeneration (cirrhosis) of the liver, by a course of hydragogue doses of cream of tartar every morning, or every other morning, with the use of iron, bark, or quinine, and nourishing diet in the day; and the patients have seemed for the time to be restored to health. Hydragogue purgatives are the more directly useful in removing ascites connected with diseased liver, inasmuch as they excite a discharge from the congested vessels themselves, and so substitute abdominal flux for abdominal dropsy (§ 381). But they often fail to excite a watery discharge from the intestines, and cause instead much irritation and tenesmus, with slimy or bloody stools: under these circumstances their use

must be discontinued; but after blistering the abdomen, or applying leeches to the region of the liver, or to the anus (§ 319), and substituting a gentler but more searching aperient containing mercury, the useful operation of hydragogue purgatives may sometimes be again obtained. Similar means will often facilitate the operation of diuretics. Dr. O'Beirne has argued strongly in favour of bloodletting in dropsy, under the impression that, by relieving the pressure upon congested vessels, it enables secreting organs to resume their activity (Dublin Journ. of Med. Sc., Nov. 1842). But like most other writers on dropsy, Dr. O'Beirne does not, as it seems to me, sufficiently regard the mixed character of the disease.

397. The unquestionable tendency which dropsy connected with diseased heart, kidneys, or liver, has to recur again and again, and to become chronic, renders it essential that the remedies employed should be varied as much as possible, as well as that the strength should be supported by all available means. It is an important point in the treatment of such cases not to exhaust the powers of any secreting organ by too long acting on it, and not to expend the efficacy of any one remedy by too long continuing its use. By employing, sometimes diuretics, sometimes purgatives, and sometimes diaphoretics, and by aiding each by local depletion, or by derivation, or by the administration of stimulants and tonics, according to the temporary prevalence of vascular fulness and excitement, or the converse, life may often be considerably prolonged. It is in the application of these rules to the treatment of protracted cases, that the skill and resources of the rational practitioner are the most tried, and his superiority over the mere routinist the most strikingly exhibited. These considerations point out why it is well to have at command a great variety of medicines, particularly of diuretics, and to alternate them with each other, or vary them, with a view to the increase or maintenance of their effect. There are in fact several great emunctory paths through which the blood constituents are mainly conveyed from the system, and medical art possesses influences by which it can at will increase the flow by any or all of these. The true eliminant medicines enter the blood, and then pass out from it through the secernent organs, stimulating and augmenting their activity as they do so. But some address themselves more to one organ, and some to another. All, however, drain away water, this being the

great carrying agent in all the vital processes. Of the five grand emunctory organs, three are chiefly devoted to the task of removing the three principal organic or constructive elements—carbon, hydrogen, and nitrogen. The lungs exhale the carbon as carbonic acid. The liver disposes of the hydrogen by converting it into fat and sugar; and the kidneys pour out the nitrogen in solution. The skin and the glands of the intestines act as auxiliaries to the lungs, the liver, and the kidneys. So that whenever it is desired to get rid of any fluid deposit, morbidly thrown down as a dropsy within the system, the effect may be produced by draining off the water of the blood through any of these several paths, by placing in the circulation medicinal agents that have no natural right to be there, and therefore will be expelled in solution. The exhausted blood then takes up the effused liquid to keep itself duly supplied with moisture. It is peculiar to the action of mercury that it increases the eliminant action of all the several excreting organs; all of them take part in the necessity of removing it from the blood. Hence the extensive range of its applicability whenever the system is in a state to support its impoverishing effect on the plastic constituents. I have often found combinations of mercury with squill, digitalis, and conium, of singular efficacy, when acute albuminuria is not absolutely present. But the greatest tact is generally required to detect the precise amount of congestive or structural change in the various sympathizing and correlated organs of the excretory apparatus, in order that those may be stimulated to increased effort which are in the best state to bear the labour. It is an interesting fact, in illustration of the frequent connexion of liver disorder with renal disease, that when the urine is laden with albumen, oil globules and fatty matter may often be detected by the microscope adhering to the shed epithelial scales. If, under such circumstances, blood be taken from the arm, the serum, after separation from the clot, is found to be quite milky from the presence of oil globules, which may be dissolved out by digestion in ether (see Dr. J. F. Duncan, in the Dublin Medical Press, June 28th, 1848). All this points to the probable close relation between albuminuria and fatty degeneration. It is in cases of this description that some beneficial result may be hoped for from the hydragogue powers of elaterium, through which the various effete matters that can no longer escape either by the kidneys or the liver, may be drained away from the large excernent surface of the intestines, estimated

at no less than 1400 square inches in the adult frame. There is here, on the other hand, very little chance that any good effect can attend the employment of saline and stimulant diuretics. But elaterium, that may thus prove so serviceable when administered at the right time, is an agent of the most dangerous kind if unadvisedly given. In dropsy supervening on cardiac obstruction, a full dose of elaterium is very apt to increase the effusion by still further debilitating the already weakened organ. It is in these cardiac cases that the diuretic treatment wears the most promising aspect. Such forms of the remedies answer best, as tend merely to diminish the water of the blood, rather than to eliminate its more solid constituents, and the dose should not be much diluted with water, or it will perchance take with it as much liquid as it causes to be carried away. Small doses of the nitrate or acetate of potash, in strong decoction of broom or pyrola umbellata, will often effect what is desired. I may also add, that among the various combinations that have proved serviceable in my hands in different forms of disorder, I may name the following:—iodide of potassium and bitartrate of potash, given with infusion or tincture of digitalis, in the dropsy consequent on scarlatina: nitrate and acetate or bitartrate of potash, or nitric acid, with juice or extract of taraxacum, where there is hepatic affection: iodide of potassium, bitartrate of potash, digitalis, and increasing doses of cantharides, in some kinds of acute albuminuria, *after* cupping the loins and administering hydragogue purgatives: ammonio-tartrate and ammonio-citrate of iron in seltzer-water, in the more ordinary asthenic states; gin, in imperial drink (cream of tartar beverage), compound spirit of juniper, spirit of nitric ether, and other stimulant diuretics under various conditions of debility. But this last class of remedies has disappointed me more frequently than any of the rest.

398. When dropsical swellings have reached a certain amount of tension, medicines produce little or no effect on them. The veins and lymphatics, whose office it is to remove the effused fluids, are too much compressed to be capable of absorbing. In the case of ascites, the pressure of the accumulated liquid impedes the circulation through the kidneys and intestines, and their secretions are proportionally reduced (§ 159). Extensive hydrothorax, and even ascites, embarrass the functions of the lungs and heart in a

similar way. Anasarca, in its extreme degrees, sometimes hinders the circulation in the vessels of the lower extremities, so far as not only to prevent absorption, but even to cause the death of the parts: hence gangrene of the legs is a common termination of incurable dropsy. The gangrene is commonly preceded by an erysipelatous kind of inflammation, which seems to originate either in some accidental scratch, or from the irritation of mechanical tension, or of the quality of the effused fluid.

Now, in all these cases, the great expedient is to remove a portion of the effused fluid, by tapping or puncturing the parts which contain it. Thus the abdomen is tapped for ascites; the chest for hydrothorax; the scrotum for hydrocele; the brain for hydrocephalus; ovarian and other cysts, when they become dropsical to a great extent; and the legs are acupunctured for anasarca. The relief afforded by these means is often very remarkable, even when a great deal of the fluid is still left behind. In fact, the main utility of these operations seems to consist in the relief of such amount of pressure and distension as seriously impedes the functions of the neighbouring organs. Accordingly, after their performance, not only is a great mitigation of suffering experienced, but also a restoration of the functions of circulation, secretion, respiration, &c., which had been mechanically obstructed. M. Lombard has shown that ascites which resists the ordinary treatment, will sometimes disappear after the accompanying anasarca has been removed by puncturing the skin. After paracentesis, diuretic and other remedies which had lost their power, become again useful, and contribute their aid to reduce the remaining effusion; and the secretions being free, the patient is able to bear nourishing food and strengthening remedies, which previously would have increased the excitement and oppression.

The usual indication that requires the use of these surgical resources is, an amount of dropsical effusion sufficient to seriously injure the functions of circulation, secretion, or respiration, other remedies having failed to give relief. Under such circumstances the operation should not be delayed. In puncturing the legs for anasarca, it is proper to bear in mind the tendency to low inflammation and gangrene; the skin and flesh should on this account be injured as little as possible; numerous punctures should be made with a fine needle, but not too close together; and as there

is more tendency to the production of this undesirable result where the circulation is weakest and most remote from the heart, it is better to puncture more above than below the knees.

After the removal of dropsical effusion by operation or otherwise, its recurrence may in some cases be prevented by the influence of pressure, skilfully maintained on the affected parts by aid of elastic bandages or belts, to which in some instances elastic air pads, made of vulcanized india-rubber, may be added, to increase the pressure in a given direction. These expedients have certainly proved serviceable in several examples of ascites, ovarian dropsy, and anasarca; in retarding or even preventing the reaccumulation of fluid. They act by giving support to weak vessels, and preventing the congestions which precede effusion. Another remedial measure, adapted only to certain forms of saccular dropsy, is the injection of a solution of iodine into the sac. It appears from repeated trials in France and in this country, that a solution of iodine, considerably stronger than that of the pharmacopœia, may be introduced into the sac of hydrocele and of ovarian tumours, and even of the peritoneum, and in dropsy of the joints, without injurious results; and with the effect of more or less preventinl the return of the effusion. The remedy certainly deserves further trials, not in such cases only, but also in serous and purulent effusions into the pleura.

Further details on these subjects properly belong to special pathology, and would be out of place here.

SECTION VII.

LOCAL HYPERÆMIA. EXCESS OF BLOOD IN A PART.

III. WITH MOTION PARTIALLY INCREASED, AND PARTIALLY DIMINISHED=

INFLAMMATION.

DEFINITIONS.

399. The morbid conditions connected with quantity and motion of the blood, hitherto described, have been pretty distinctly defined; and we have been able to refer many phenomena of dis-

ease to them. We now come to another of the same class, the name of which is very familiar, and whose frequent occurrence gives it so high an importance, that it has always attracted great attention amongst pathologists: but although so commonly occurring, this condition is of a much more complicated nature than any of the morbid elements previously considered; in fact, it may be said almost to comprehend them all, besides being a still further deviation from the natural condition.

The terms *inflammation, phlegmasia,* and *phlogosis,* have been used, from a very remote period, to denote collectively the heat, redness, burning, and painful sensations which commonly exist in inflamed parts. These symptoms are so frequently seen, and have hence become so familiar, that inflammation has long been distinguished as a chief element of disease; in fact, it has, in a measure, engrossed the attention of pathologists so exclusively, that other important elements have been almost overlooked; and this oversight has not only retarded the advancement of our knowledge with regard to these other elements, but it has also rendered the subject of inflammation itself less intelligible, by excluding the consideration of some of its component parts, and by keeping it in its complexity and remoteness from the normal conditions of function and structure. It will be found, that an acquaintance with the ultimate and proximate elements of disease, already considered in this work, is essential to the proper comprehension of the nature of inflammation; for these form the connecting link between the natural properties of living textures, and the extreme of departure therefrom, which is presented in this state. The pathological definition given above, to distinguish inflammation from the other varieties of hyperæmia—*too much blood in a part, with motion* (of that blood) *partially increased, partially diminished*—is illustrated in the strong pulsation of arteries leading to an inflamed structure, and in the stagnation of much blood in the structure.

400. But in addition to this pathological definition, the outward character of inflammation may also be briefly defined by the four signs which, from the time of Celsus, have been considered distinctive of its presence, namely *redness, heat, pain,* and *swelling.* These symptoms are, it is true, sometimes produced by congestion (§ 303), and by determination of blood (§ 333, &c.); but in a degree less marked, and for a time less continued, than in inflammation; and although there are cases and forms of inflammation

in which it is not possible to detect all these marks, they may still be said to constitute its most general character. In common with other varieties of local hyperæmia, inflammation owes the production of redness to the excess of blood in the part, but we shall find that this redness is heightened by a peculiar concentration of the blood corpuscles in the inflamed vessels, and that this is also the cause of some of the peculiar results of the process. As in determination of blood, the heat and pain are in part due to the increased motion of the blood; but they are exaggerated by the motion being opposed to obstruction. As with other forms of hyperæmia, the swelling arises partly from the over-distension of the blood-vessels, and partly from effusions from them; but these effusions in inflammation differ from those of congestion and simple determination, for they depart still further from natural quantity and quality.

CAUSES OF INFLAMMATION, AND THEIR MODE OF OPERATION.

401. *Predisposition* to inflammation has been already noticed under the head "predisposing causes of disease" (chap. i. sect. 2). The circumstances which render the body liable to inflammation are those which especially affect the vascular system, whether these circumstances be the result of original conformation, as the sanguine temperament (§ 38); or whether they be the effect of previous disease (§ 31), of present disease (§ 34), or of external or internal causes in actual operation (§ 20, *et seq.* 30). Inasmuch as various circumstances, external or internal, tend generally or locally to impair the healthy tone and balance of the vascular system (§ 123), whilst muscular irritability (§ 112) and the quantity of the blood are not proportionately reduced (§ 195), they so far predispose to inflammation. Accordingly, we find persons prone to inflammation to be those whose circulation has been weakened or irregularly excited by previous disease, fatigue, confinement, impure air, or improper nourishment. But it will presently appear that the predisposition differs according to the nature of the cause which excites inflammation; those who are most subject to it from causes acting generally, suffering less than others from causes which act only locally. Thus a depressed state of the whole vascular system favours the production of inflammation by causes acting generally (such as cold); whereas an excited state of the

vascular system favours the development of inflammation from local irritation.

402. The concluding passage of the last paragraph prepares us to divide the *exciting causes* of inflammation into those which act locally on the part which inflames, and those which act more generally on other parts. The operation of the first class is direct; that of the second is indirect, and therefore less certain, and more dependent on predisposition.

The *local* exciting causes of inflammation comprehend *irritants*, whether *mechanical*, *chemical*, or *vital*. A grain of sand in the eye, a thorn in the true skin, and a bruise or wound in the flesh, are examples of mechanical irritants, acting as sources of irritation. Chemical irritants are such agents as operate on living matter by strong chemical affinity, and tend to alter or decompose it (§ 53); heat, strong acids and alkalies, various corrosive salts, chlorine, and iodine, are of this kind: such act in like manner on dead textures. Vital irritants are various agents, which produce no effect on dead animal textures, and whose irritating operation is not referable to any known chemical property; of this kind are cantharides, mustard, capsicum, and essential oils. In this last class must also be included various animal and vegetable irritant poisons, such as the matter of small-pox, and the venom of some noxious animals and plants, which act as local irritants, besides otherwise affecting the system. Various noxious matters, generated in the living or recently dead body, are also capable of exciting inflammation when applied to an abraded surface (§ 258). Nay, the natural excretions of the body themselves prove to be most acrid irritants, when brought into contact with serous and cellular membranes; thus urine, fæces, and bile, if effused into serous membranes, even in the smallest quantities, produce intense irritation and inflammation. Frost-bite, or intense cold acting on a part, appears to permanently injure the functions of living textures, so that the returning circulation establishes a process of inflammation in the parts less affected.

Irritation and inflammation are sometimes caused by excrementitious matter accumulated or retained in the blood in consequence of derangement of the functions of the excernent organs (§ 249, 251, 254). Local inflammations are also excited by certain poisons received into the system: thus arsenic, even when applied to a wound, causes inflammation of the stomach and intestines;

mercury excites inflammation of the gums; phosphorus that of the bones of the jaws; the poisons of small-pox, scarlatina, and measles, inflame the skin, throat, and air-passages; the poison of syphilis affects the periosteum, throat, skin, and iris in like manner. In these cases, there can be little doubt that inflammation is excited in the parts which inflame, by the actual presence of the peculiar irritating matter,* conveyed there in the blood; and it is a frequent character in the operation of these irritants which are conveyed through the blood, that it affects several parts, or a considerable portion of the body at once; and frequently the two sides of the body in a similar manner. This is observed in the eruptions of exanthematous and other skin diseases, in rheumatism and gouty affections allied to it, in syphilitic nodes, &c. (§ 259.)

It is highly probable that the presence of an irritating matter in the blood is a very frequent cause of inflammation, even in cases that are not considered specific. There is good reason for supposing that common catarrhal inflammations are in some degree due to an influence of this kind, brought into operation by changes of the temperature or moisture, which disturb the balance of the circulation. This constitutes one predisposition to catarrhal affections, rendering a person liable to "catch cold," which consists in the development of a local inflammation by the joint operation of the change of temperature and of the peccant matter in the blood; and this matter being eliminated from the system during the inflammatory movement which follows, the system is left for a while free from the predisposition. Thus may be explained the almost periodic return of catarrhs, to which many persons are subject, and which bears much analogy to the accessions of gout and other cumulative disorders. The same pathological principle is indicated also in the popular term, "heat in the blood," which not inaptly designates the peccant humour.

403. The second class of causes exciting inflammation, those which operate indirectly, are of very common occurrence; and, although comprising fewer agents, they as frequently produce diseases as the more direct causes. They include influences which

* The late Mr. Durance George showed me portions of the jaw-bone of a person who had taken mercury largely: globules of the metal were distinctly visible in the cancellæ of the alveolar processes.

first produce congestion, that is subsequently converted into inflammation on the occurrence of reaction. The most common of these is cold, which, both by its local operation (§ 76), and by its more general application (§ 77), may produce congestions (§ 296, 292), that ultimately pass into inflammation. Malaria and the poisons which induce continued and eruptive fevers, produce congestions (§ 293), and thus often lay the foundation of inflammation, which then complicates the febrile affections directly excited by the same causes. Inflammations sometimes arise out of the congestions caused by venous obstruction (§ 289), and mere gravitation. Thus pneumonia (with hepatization and sometimes with suppuration), frequently occurs in connexion with disease of the heart, that impedes the circulation; also in adynamic fevers, and in the sinking which precedes death (§ 290). The congestions of blood in the lungs, brain, and mucous membranes, that from the application of various asphyxiating causes (§ 298), times end in inflammations, which then become a chief source of danger after the restoration of the respiration (§ 235, 243).

404. Suppression of natural or habitual discharges, (especially the catamenial,) the sudden drying up of ulcers, and the repulsion of cutaneous eruptions (§ 69), are recognised causes of inflammation (§ 67). When the inflammation excited by these causes is in, or contiguous to the parts previously affected, local irritation may have a share in producing it; but when it is in distant parts, it probably results from a congestion or local determination of blood, which then belongs to the second class of causes just specified. Very probably some of these causes of inflammation have a twofold operation, that just specified (producing a local fulness), and that of local irritation by morbid matters introduced into the circulating mass of blood. Thus the visceral inflammations arising on the sudden healing of a suppurating wound may be promoted by local congestions resulting from the cessation of the purulent discharge; but their circumscribed character, and the uniform event to which they tend (suppuration), seem to indicate that the presence of a morbid matter in the circulating blood is their exciting cause, and microscopical researches have confirmed this inference. The same remark applies to the inflammations of the skin, fauces, and mucous membranes that occur in scarlatina,

measles, and small-pox; to the follicular enteritis of typhus,* and to the visceral complications of erysipelas, and other specific febrile affections. In all these, besides a general tendency to internal congestions, we seem to trace the irritating operation of a morbid poison on particular parts.

405. We have noticed that sthenic hæmorrhages (§ 363) and fluxes (§ 393), if too speedily checked without sufficient reduction of the circulation, are apt to pass into inflammation. So likewise determination of blood, if long continued, may issue in inflammation (§ 340). The causes which excite determination of blood when applied in a greater degree, or for a longer time, excite inflammation.

406. Before we proceed to examine into the nature of inflammation, we may properly inquire what is the mode in which its causes operate. It has been generally assumed that the first movement of inflammation, as of all other pathological processes, is to be found in the nerves; but this is by no means proved. That some causes of inflammation (irritants) operate first on the nerves, is probable from the following considerations. 1. Their action on the sensitive nerves *is felt* long before inflammation begins; thus the prick of a thorn in the skin, the smarting of caustic on a wound, the pain of the sting of an insect, are felt instantaneously; there is first nervous irritation; inflammation follows after. 2. The irritation is sometimes transferred to other parts by sympathy, of which nerves are the channels: thus strong irritants applied to the nostrils may cause inflammation of the conjunctiva;

* I have observed an extraordinary enlargement and inflammation of the isolated and grouped glands of the intestines in the bodies of persons poisoned with arsenic. Their enlargement in epidemic cholera, and in the severe form of sporadic cholera, diarrhœa, and dysentery, caused by putrid effluvia, is well known. Are these glands excretory organs for the elimination of poisonous or noxious matters from the system? and in typhoid fever, do they become inflamed and ulcerated by the continued operation of the poison in the exercise of this function? The favourable influence of moderate diarrhœa in fever, the uncommon fœtor of the stools, the general relation between the duration of the fever and the affection of these follicles, the salutary operation of mild mercurial remedies, which promote their secretion, and other facts that might be adduced, give so much countenance to this view, as to make it worthy of attention.

The preceding surmise, put forth in the first edition of this work (1843), has received corroboration from numerous facts subsequently observed, and it seems to me to indicate the true cause of the intestinal complication in fevers and other diseases induced by a morbid poison in the system. Dr. Carpenter has recently advocated this opinion, and further applied it to account for the fœtid and colliquative diarrhœa which often occurs in states of much depression (Human Physiology, 1853, p. 207).

the long-continued exertion of one eye in using the microscope, may induce inflammation in both eyes; a calculus in the urethra may excite inflammation in the testicle (Paget); a carious tooth or a diseased bone may irritate and inflame parts which are not contiguous to it. 3. An injury to a nerve is sometimes followed by inflammation in parts connected with this nerve. Thus paralyzed limbs are liable to become inflamed. Lallemand relates a case in which a ligature, involving the right brachial plexus, was followed by inflammation and suppuration in the opposite hemisphere of the brain.

407. On the other hand the following arguments may be adduced to show that the cerebro-spinal nerves at least are not essentially the seat of the first stage of the process of inflammation. 1. Some of the causes of inflammation (the majority of those inducing internal inflammation) produce no known primary effect on the nerves or nervous system: thus inflammations excited by cold are often preceded by no marked nervous disturbance; and the strongest impressions of cold on the nervous system are frequently not followed by inflammation (§ 77). 2. Inflammations often originate in congestions (§ 403) and in the sudden suppression of hæmorrhages and other discharges (§ 405), without the occurrence of any symptoms referable to the nerves: hence inflammations thus arising may escape detection, and are called *latent*. 3. Persons in whom nervous properties are most developed (§ 126, 152, 156), are not the most susceptible of inflammation; and all varieties of nervous excitement are sometimes manifest in the highest degree without any inflammation ensuing. Even where pain and other nervous symptoms are excessive, and are the result of mechanical or chemical injuries (such as crushed limbs, extensive burns, &c.), inflammation sometimes does not follow; and this has led surgeons long to distinguish between irritation and inflammation. 4. Inflammation is readily excited in parts whose nerves are paralyzed, or have been divided: in fact, it sometimes occurs spontaneously in them. The experiments of Bernard seem to limit the influence of the nerves over the blood-vessels to the sympathetic system, in accordance with views previously held by Dr. Copland and others. But these experiments seem to prove that this nervous influence prevents inflammation instead of causing it. Thus when a branch of the sympathetic nerve is divided, the parts supplied by it spontaneously become the seat of determination of blood and subse-

quently of inflammation. It is plain therefore that an injury to the sympathetic nervous function may become a cause of inflammation: but it is by withdrawing nervous influence rather than by any positive operation.

408. Seeing, then, that inflammation is frequently excited without any obvious affection of the nerves, and is often not excited when nervous irritation is most intense, it cannot be inferred that an impression on the nerves is an essential part of the process of inflammation. That the nerves are concerned in many of the phenomena of inflammation, and in its extension, is fully admitted; and in the case of excitement of inflammation by irritation, the primary operation of the exciting cause, even on the sensitive nerves, has been already pointed out (§ 406). Possibly there may be a primary action on the sympathetic nerve or some of its branches which have an influence over the blood-vessels, but until this is made more evident by further research it cannot profitably be dwelt on. So far as is known, the blood-vessels are the seat of the whole process of inflammation; and although some of the exciting causes of the state (§ 402, irritants) act on the nerves as well, yet others (§ 403, as cold) operate essentially only on the blood-vessels. We find that the causes predisposing to inflammation (§ 401) are circumstances chiefly affecting the vascular system. A review of the exciting causes of inflammation (§ 402, 405) will show that in their mode of operation on the blood-vessels they may be divided into two classes: 1. those that cause determination of blood (§ 322—324); and, 2. those that produce congestion (§ 290—299). The former class comprehends all irritants (§ 402); the latter class includes cold and other agents which directly produce congestion (§ 403, 405). We have several times had occasion to mention that determination of blood, when exceeding certain limits, is apt to pass into inflammation (§ 340); and that local congestions are liable to be converted into inflammation (§ 292, 293, 306).

PHENOMENA AND NATURE OF INFLAMMATION.

409. Having noticed the causes of inflammation, and traced their essential operation to the blood-vessels and their contents, we have next to inquire what the character of that operation on the vessels is, and what the phenomena are that it develops.

That the blood-vessels are enlarged in an inflamed part might be inferred from the increased redness manifest to the naked eye. But in what respect does inflammation differ from congestion, in which also the vessels are enlarged? It differs not only in the accompanying symptoms, and in its results, but also in the observed condition of the vessels of the part. Thus, besides greater pain and heat, and earlier and more abundant effusions, the more florid hue of the redness, the strong beating of the arteries leading to the part, and the augmented quantity of blood flowing from its veins, clearly indicate that there is increased motion of blood, instead of diminished motion, as in congestion (§ 287).

Casual observation of the pulsation of arteries leading to inflamed parts, suffices to show that there is determination of blood to them; and some experiments performed by Dr. Alison and others have also proved that these arteries are enlarged.* It was found that the arteries leading to the inflamed limb of a horse were considerably larger than those of a sound limb. John Hunter had arrived at a similar conclusion from experiments on the ears of a rabbit. Now this enlargement has been traced to diminished tonicity in the affected arteries, a state which is the chief instrument in causing determination of blood (§ 326, 327).

That the motion of the blood is increased through an inflamed part, is distinctly proved by the observation of Mr. Lawrence; venesection being performed at the same time, and in the same manner, in both arms of a patient who had an inflammation in one hand, a much greater quantity of blood flowed from the vein belonging to that hand, than from that of the other arm.

410. It is certain, both from the preceding facts, and from direct observation by the microscope, that determination of blood is present in inflammation. The vessels in the vicinity of the inflamed part receive an increased flow; there is an augmented flux of blood towards the whole of it, and through some of its vessels. But if this were all, there would be no distinction between determination of blood and inflammation: the greater redness and swelling, and the peculiar character of the effusion, however, point out that inflammation is not mere determination. Microscopic research has established one great point of difference. The observations of Thomson, Hastings, Kaltenbrunner, and Marshall Hall, have long clearly proved that there is more or less *obstruction* to

* Trans. of British Association, 1835.

the passage of the blood in the vessels most inflamed. Thus in the web of the frog's foot, when a part inflames from local irritation, the blood is seen to move more slowly where the irritation is greatest, and gradually accumulating in the vessels there, it renders them larger, redder, and more tortuous, until at length the motion ceases altogether in them, whilst neighbouring vessels are still permeated by an increased current. A chief point then in which inflammation differs from determination of blood, is that there is retarded or arrested flow of blood in some of the vessels. This answers to the definition of inflammation already given: *too much blood in a structure, with motion (of that blood) partially increased, and partially diminished* (§ 399).

411. The question now naturally arises—What is the cause of the obstructed or retarded flow of blood through an inflamed structure? This has ever been the chief difficulty in the pathology of inflammation; and it is especially to solve this that various hypotheses have been framed. Thus Cullen supposed a spasm of the extreme vessels to be the cause of obstruction, and therefore the proximate cause (§ 13) of inflammation. Dr. Wilson Philip ascribes the same obstruction to a weakness of the capillaries which he presumes to incapacitate these vessels from transmitting the blood. John Hunter considered that there is something more active and vital in the enlargement of inflamed vessels, and he applied to it the term "active dilatation." The analogous expressions, "vital turgescence," "turgor vitalis," "inflammatory erection," used by Kaltenbrunner and other German writers, imply a similar notion.

The hypothesis of Cullen is quite inconsistent with direct observation, the extreme vessels being seen under the microscope to be in a state of dilatation, and not of spasmodic contraction. This observation corresponds better with the idea of Dr. W. Philip, which was indeed founded upon it: but it has been objected by Dr. Marshall Hall and others, that since the capillaries do not aid the circulation of the blood by their contraction, their "debility" cannot be a sufficient cause for interrupted passage of blood through them. The words used by Hunter scarcely convey any meaning that can be accepted as an explanation. They may be interpreted to assume the existence of a self-expansive power in the vessels, which power is supposed to act in inflammation as well as in natural formative or plastic processes in the animal body.

But the existence of such a power is quite at variance with all that is known of animal physics. A part may be expanded by elasticity, or by the injection or retention of fluid in it, but no direct vital expansile power has been ever proved to exist. The apparently active expansion of the heart, in its diastole, may be ascribed to the natural elasticity of the organ, and the increasing weight of its contents, suddenly enlarging its size on the cessation of its antagonizing systole: neither its structure nor its mode of action countenances the notion of a vital dilating power.

412. Haller and some of his followers ascribed the circulation of the blood in part to certain supposed properties of vital attraction and repulsion, by which the blood is drawn into, or repelled from particular parts, independently of all motion of the living solids. These opinions have been recently advocated with much ability by Dr. Alison and others, who consider changes in these assumed vital attractions and repulsions to be the chief elements in the process of inflammation, as well as in other pathological conditions in which the blood and its vessels are mainly concerned.*

* See Alison's "Outlines of Pathology and Practice of Medicine," 1843, p. 122. Several of Dr. Alison's arguments in favour of the existence of "vital attractions and repulsions" are founded on certain physiological facts, which he considers inexplicable in any other view. It belongs properly to works on physiology to discuss these matters; but I would here express the opinion that none of these arguments seem to me to be satisfactory. The motion of the sap in the chara and other vegetables may be well explained on the principle of osmose and exosmose. A fluid of lower density (water) chemically acts on and penetrates membranous tubes, containing a liquid of greater density (sap): that which begins a flow into the tubes, may sustain it in continued current through them so long as the difference in density and composition between the water and sap subsist. A similar principle doubtless aids the motion of fluids in the animal body in some instances; in others the movements observed (as in the air-tubes, genito-urinary passages, &c.) have been traced to the vibrations of cilia, and are therefore no proof of the existence of vital attractions and repulsions.

It is said that when an artery is tied, the blood ceases to run in the open part of it, and passes away by adjoining branches, which become enlarged in proportion, whilst the tied portion becomes empty. It has been supposed that the blood here spontaneously leaves the part of the artery through which there is no passage. I demur to the correctness of the statement, and still more to the explanation. Every one who has witnessed great surgical operations must have noticed the strong pulsation above the ligature of tied arteries; and the occasional occurrence of secondary hæmorrhage shows that the blood has no inherent disposition to pass in a new direction. No doubt in time the artery ceases to receive blood into its tied portion; but this is because either a coagulum is formed where the current cannot pass, or the tonicity of this portion effects the contraction of the tube, the force of the circulation being diverted into the contiguous enlarged branches. Here is no proof of any self-motory and self-directing power in the blood. I have before stated that all my own microscopic observations have failed to detect in the blood any spontaneous motions, independent of contractions of the solids or of currents caused by ciliary

This hypothesis needs the most ample proof before it can be received. It assumes the existence, in the fluids as well as in the solids of the living body, of properties as distinctive and as peculiarly vital as that of contractility or sensibility. It ascribes to these fluids and solids powers of attraction and repulsion at *sensible* distances, like the attractions and repulsions of electricity, magnetism, or gravitation, yet distinct from all these, and sometimes opposed to them. It attributes to the living body a new physical power, and almost a discerning intelligence in the exercise of that power. Now, before the existence of such a power can be entertained, it must be proved that the phenomena under consideration are not, and cannot be, explained through any known vital or physical agencies. We have already adduced, and referred to, arguments and observations which tend to the view that the *known* physical and vital properties of the living body do account for the chief phenomena of health and disease, without assuming the existence of any forces of a mysterious character; and we have now to consider whether the same thing is not the case with regard to inflammation. If we succeed in explaining the nature and effects of inflammation by a reference to ascertained properties, it will be needless and unphilosophical to assume the existence of others, which are mysterious and unknown.

413. We have already stated (§ 408) that inflammation may originate either in determination of blood, or in congestion; and we now proceed to show that it essentially comprises both these elements in itself. The mode in which the process of inflammation has been chiefly studied, is by observing under the micro-

motion, osmosis and exosmosis, and such physical influences. The oscillatory motion said to have been seen by Haller and Kaltenbrunner in the small bloodvessels of inflamed parts, "even after the heart is at rest," may, perhaps, be ascribed to the tonic contraction of the arteries, which, although gradual in itself, is often seen to act by jerks on partially obstructed vessels. A similar oscillatory movement is sometimes communicated to capillary vessels by the quivering contraction of adjoining muscles. Another observation of Haller mentioned by Dr. Alison, that of "blood escaping from vessels between the layers of a living membrane, and nevertheless pursuing its course in a regular stream for a time, even against the influence of gravity," may be fairly referred to the *vis à tergo* from the open vessel. In the fluids of such a nicely adjusted hydraulic apparatus as the vascular system of animals, and even vegetables, it is surprising how readily motions may be produced by various physical causes; and when these motions are magnified by the microscope, it is not wonderful that they should have been mistaken for vital movements of the fluids themselves. It may be further added, that rhythmical contractions have been observed in some instances in the veins of lower animals; as by Dr. M. Hall, in the tail of the eel, and by Mr. Wharton Jones, in the wing of the bat (Philosoph. Trans., 1852).

scope the effect of irritants on the web of the frog's foot. It must be remembered, however, that this is only one mode in which inflammation may begin, and we shall hereafter find that many of the lower vertebrate animals fail to exhibit some of the most remarkable results of inflammation. But observations have also been made on the circulation in the wing of the bat, with very similar results.

The effect of weak irritants on the vessels of the frog's web has been described before (§ 294, 326). It was there stated that irritation may cause first determination of blood, and then congestion; these results being dependent on an enlargement respectively of the arteries, and of the veins and capillaries. But if a strong irritant (as a grain of capsicum, or a minute globule of essential oil*) be applied to the web, all its bloodvessels speedily become enlarged: those most irritated are very large and red, and the blood in them is stagnant and coagulated: contiguous vessels are also very large, but less red, and the motion of the blood in them is slow, and often in pulses or oscillations; whilst in vessels beyond, the enlargement of the capillaries is less considerable, but that of the arteries is obvious, and the current of blood is very rapid.

Now, it is obviously the stagnation or tardy motion, of blood in enlarged capillaries, in the midst of surrounding increased flow, that characterizes inflammation; we have, however, still to inquire what is the cause of the stagnation. This cause must be either in the vessels, or in their blood, or in both. The latter we shall find to be the true case.

414. We have already pointed out (§ 300) that atony and flaccidity of bloodvessels may become a cause of impediment to a current through them, not by preventing these vessels from actively contracting on their contents, (for they have no such power,) but by removing that tone by which the vessels maintain the calibre and the tension best calculated to transmit onwards the force of the current. Vessels thus weak and inelastic, instead of equally conveying the current, become distended, lengthened, and tortuous on receiving it; and by the very mass of their contents, as well by their inelasticity, they partly break the force of the current, and partly turn it into other channels. The mode in which this results in inflammation will be better understood, if we review other local modifications of the circulation in comparison with it.

* These are preferred because they produce no chemical change in the parts.

In determination of blood, the arteries are enlarged, and so are the capillaries in moderate proportion; the circulation is therefore equally increased. In congestion, the capillaries are greatly enlarged, without any increase of the arteries: the motion is therefore impaired; but still it may diffuse itself through the mass of the blood, which moves slowly. But if to congested capillaries there be added the increased and abrupt force of the current from enlarged arteries, or if to determination of blood (enlarged arteries, § 326) an atonic congestion of the capillaries be joined, the propulsive power of the current will be impaired. As in the experiment with the intestine (§ 300), the blood will pulsate or oscillate in the distended vessels rather than pass through them; and the main current will pass through collateral anastomosing channels, which then become the seat of simple determination or increased flow. This is just the state of things in the incipient stage of inflammation; and if either the capillaries do not speedily recover their tone, or the arteries do not contract, the blood becomes stagnant in parts, its particles adhere to each other, and to the walls of the vessel, and the obstruction is confirmed. Some of the capillaries still remain in their arterial portions open, and exposed to pulsative force from the supplying arteries, which continues to strain their coats, and causes an oscillatory motion of their contents, but no passage through them. Such are the phenomena which we see under the microscope.

It may, then, be fairly inferred that one cause of the stagnation or retardation of the motion of the blood in the inflamed part, is a weak, inelastic state of the capillary vessels;* such, in fact, as exists in cases of atonic congestion; on referring to the causes of inflammation (§ 404), it will be perceived that many of them act by first producing congestion. Nay, we have found (§ 294) that even irritants, in some measure, operate in the same way. "The

* It may, perhaps, be objected that I have supposed a similar atonic state of the arteries to be the cause of an increased flow through *them*, and to be the physical cause of determination of blood. But this is no objection. The arteries, as compared with the capillaries, are few in number; the current in them is rapid; they are exposed to the pressure of a *vis à tergo* which maintains the velocity of that current, whatsoever may be their calibre: when their coats lose some of their tone, this pressure of blood into them stretches them to tension, and they thus admit an augmented force and volume. In capillaries, on the other hand, the current is so much subdivided and straitened, that it is easily disturbed, and the motion, naturally tardy, is readily arrested, and this the more surely in proportion as the blood ceases to undergo the changes which naturally favour its passage through them (§ 295, note).

continued application of stimuli to a part is sometimes followed, not by inflammation, but by congestion. This especially happens in the liver, a chiefly venous organ; but it occurs also in other parts. It might be supposed that the stimuli act by exhausting the contractility of the small vessels, and thus leaving them weakened and distended by their contents. . . . . But on the application of a strong stimulant, such as a minute particle of essential oil, the previous arterial contraction is not apparent, and the enlargement is speedy and obvious, causing extreme rapidity of motion and enlargement in all the vessels. In a few minutes, the size of the arteries begins to diminish, and with it the motion in the capillaries beyond them. Many of the capillaries still retain their enlarged dimensions; in them the motion is most sluggish, and, in some parts, ceases altogether."*

415. But it is very certain that the obstruction and much of the other features of inflammation, are generally dependent on changes which take place in the blood within the inflamed vessels. J. Hunter did not overlook this; and, besides describing the coagulation of the blood in the most inflamed vessels, he mentions the adhesion of fibrin to their interior. The coagulation of the blood in the inflamed vessels was also noticed by Gendrin and others; and Dr. Marshall Hall attributed the obstruction of the vessels in inflammation to the adhesion of blood-globules to the walls of the vessels.

Poiseuille, in his observations with regard to the motionless layer of serum which intervenes between the moving blood and the walls of bloodvessels, had noticed that the blood corpuscles sometimes get into this still layer, and either remain fixed there, or move onwards more slowly than the rest of the blood. In repeating this observation with Mr. Toynbee, we remarked that it was not the red corpuscles, or elliptical blood discs, that thus adhered to, or slowly rolled along the sides of the vessels, but the white or colourless bodies (§ 212), called by Müller, lymph globules. (The following description is taken from my Gulstonian Lectures, of 1841):—"I have never seen a solitary elliptical disc adhering to the sides of a vessel; and whenever one was arrested in its course, it was from its becoming hitched by one or more of the adherent round globules. But what appeared to me most remarkable with

* Extracted from the author's Gulstonian Lectures for 1841; Med. Gaz., July 16 1841.

regard to these white globules, was the great difference in their number under different circumstances. In young frogs, and in those much subjected to experiment, they are always present in great numbers; but in healthy adult frogs, placed under the microscope with as little handling of the web as possible, there were comparatively few to be seen." It is under these circumstances that the effect of irritation or mechanical injury was best seen. "By pressure of the finger on the web, partial stagnation was produced in many of the vessels; and when this yielded to the returning current, the walls of the vessels were seen studded with the white globules; whilst many others of the same kind rolled over them slowly in the direction of the current. I have before mentioned (§ 294), that a similar result ensued after the web had been stimulated by capsicum or an aromatic water. Even in the rapid flow of blood following these applications, minute globules could be seen creeping slowly along the transparent outline of the larger vessels; and as the arteries contracted, and the flow through the other vessels became less rapid, the number of these globules increased, their motion became slower, and many adhered to the sides of the vessels. If the stimulus used was rather strong or long applied, the number of sticking globules was so great as to prevent the red corpuscles from passing; and these becoming impacted in increased numbers, gave to the obstructed vessels a uniform and deeper red colour. When the stimulation was moderate, and equally applied to the web, the stagnation usually took place first in some of those anastomosing veins in which the current is naturally slow and varying in direction; but when a stronger stimulus (as an essential oil) was used, the stagnation speedily ensued at the point of its application; in fact, unless very minute quantities were employed, the stagnation was almost immediate and extensive."*

* Med. Gaz., July 23, 1841. It was not until after these observations were made that I became acquainted with similar ones, previously published by Mr. Addison, of Great Malvern, in the Med. Gaz. of Jan. 29th of the same year. The following description is given by Mr. Addison:—"In the frog's web, two days after the application of *salt*, in some of the larger capillaries or smaller veins, there are a great number of globules, No. 3," (lymph globules); "and it is quite extraordinary to observe the difference in movement between these round speckled globules and the oval ones; the blood globules pass in a continued stream, while in the same fluid, in the same vessel, are a great multitude of other (lymph, No. 3) globules, which do not move, or do so very sluggishly; every now and then they move slowly, apparently urged on by the repeated knocks they receive from the blood globules. It would appear, that after the capillary vessels have been acted

416. I varied these observations in a great many ways, and always found considerable or continued irritation of the vessels in the frog's web to be attended with the appearance and adhesion of the colourless globules; and that when the irritant used is at all strong, or frequently applied, many vessels become totally obstructed, get larger and redder in consequence of the accumulation of red corpuscles in them, (the blood liquor having passed on,) and exhibit to the naked eye all the appearance of inflammatory injection. One cause of obstruction seems to be comprised in two circumstances—*the increased production of white globules*, and *their remarkable disposition to adhere to the walls of the vessels and to one another*. It must however be stated that Dr. Hughes Bennett and Mr. Paget do not admit that the appearance of the pale corpuscles is so constant or essential as I have described it. In his observations on the circulation in the bat's wing, Mr. Paget traced the production of inflammation when very few pale corpuscles were present; and he considers their abundance in frogs to be an indication of unhealthiness in the animal. I much regret that my engagements do not permit me to return to these investigations; which I cannot consider as definitively concluded by the negative observations since made. Of the abundant production of pale corpuscles in the frog's web under irritation, I have still no doubt; but that the same takes place in warm-blooded animals may be questioned, after the statements of Messrs. Paget and W. Jones. Still Mr. Gulliver assures me that he never failed to find pale corpuscles more or less abundant in the blood taken from inflamed parts of human subjects previously healthy, in whom a phlegmonous inflammation was the result of an accidental injury. He also considers the inflamed vessels to be the seat of an increased cell-formation. Such positive observations should have at least

on by the salt, the round (lymph) globules accumulate in an unusual manner, and the blood globules repeatedly slide over and knock against them. In some of the vessels, there is a rapid stream of blood in the centre, whilst at the circumference there are many stationary, round, spotted globules, which do not obey the impulse which urges the stream of blood, but remain, or move on slowly by little starts, at uncertain intervals, and with unequal pace." This account corresponds very exactly with what I have myself observed; but I should not consider the experiment so conclusive with regard to inflammation, inasmuch as the chemical action of the salt might have been concerned in the production of the lymph globules. In my observations, I was careful to use no irritant which has any known chemical action on the blood. The greater prevalence of the pale globules in the motionless layer had been noticed by Wagner and others; and their more abundant production in inflamed parts has been mentioned by Mr. Gulliver.

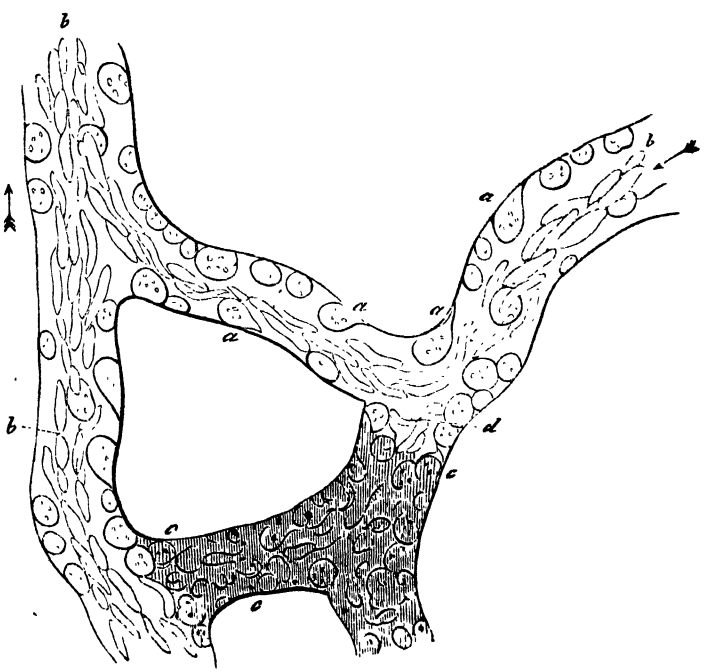
as much weight as opposite ones, which are negative; and it may be remarked that the pale globules may escape notice in vessels in which the blood is stagnant, from their being completely covered by the red corpuscles which are found among them.

The origin of the white corpuscles (§ 195), seen in the blood, is involved in some doubt. They are distinctly spheroidal bodies, of a gelatinous consistence, and composed of granules, some of which have the distinct appearance of nuclei. According to Mr. Addison,* they are invested by a delicate membrane, and are granular cells, which, slowly by the action of water, more promptly by the operation of solution of potass, are caused to burst and discharge granules and molecules. In this respect, the colourless corpuscles differ from the blood-discs, which burst speedily under the same treatment, and are almost dissolved by either of these fluids. They appear to consist of fibrin, or rather deutoxide of protein; and, as in the case of other granular bodies formed in an albuminous fluid, each granule probably has a central nucleus or molecule of fat, which makes their specific gravity lower than that of the red corpuscles: hence their disposition to collect in the buffy coat of inflamed blood. The increased number of these bodies within the vessels of an inflamed part has been observed by Mr. Addison as well as by myself; and from careful comparison instituted with uninflamed vessels, I infer that this increase is due, not merely to their being *arrested* in their transit through the inflamed vessels, but to their being actually formed in greater numbers, and that there is thus in the inflammatory process an increased cell-formation within the vessels. Nor is it difficult chemically to account for this production, if we consider the combination of causes which are operating in inflamed vessels. The blood liquid is highly charged with protein, which needs only a further process of oxidation to make it assume the solid form of deutoxide: this process is supplied by the free current of arterial blood (determination) which rushes into the obstructed portions, and brings the red corpuscles, the oxygen carriers, in such forcible contact with blood liquor as favours the transfer of oxygen to the protein contained in it. As the protein becomes oxidized, it consolidates in a granular form, and the more readily around the oily molecules always diffused through the blood liquid; and these form the granules. But the granules also cohere in clusters, and

* Trans. of Provincial Med. and Surg. Assoc., 1843, p. 240.

form the pale corpuscles of various sizes which appear adhering to and creeping along the sides of irritated vessels.* This explanation corresponds with the sudden manner in which such numbers of pale corpuscles appear in the vessels of the frog's web, not only after its continued irritation, but also after its momentary rough

* The accompanying diagram exhibits the appearance of a small portion of the capillaries of a frog's web after the application of a particle of capsicum; and although perhaps not representing a type of healthy inflammation in a warm-blooded animal, yet probably it affords some illustration of the process in its lower forms. The elliptical blood-discs (*b*) are running in the axis of the vessel, which is much narrowed by white globules adhering to the walls, or only slowly rolling along them. These globules are speckled with nuclei or granules, refract the light strongly, and when rolled on by the current, some of them become pear-shaped from their sticking to the vessel, thus forming a kind of dragging tail, seen very well in those marked (*a*); on altering the focus, similar globules may be seen adhering to the other parts of the vessel. The shaded portion (*c*) is totally obstructed with white and red corpuscles, so impacted together as to form a homogeneous red mass. I have often seen the particles at (*d*) exhibit a pulsating or oscillatory motion, (corresponding with the action of the heart;) which, after a time, has seemed to succeed in breaking down the obstructing mass, which then has passed away in clots, leaving the vessel (*c*) studded with pale corpuscles like the rest; this result is observed whether the obstruction have taken place suddenly, or slowly, showing that in either case these corpuscles are present.



handling or squeezing, whereby the vessels are partially obstructed, and so the force of the arterial current directed on their contents; the walls then appear studded with adherent and creeping corpuscles; but as the impediment and the determination are not permanent, the lingering corpuscles are soon swept away and disappear: in inflamed vessels, on the other hand, their presence is more constant; and their abundance in the blood in inflammation has been long since noticed by Gendrin, Gulliver, Addison, and others; although more recently questioned by Mr. W. Jones and Mr. Paget.

417. We have next to notice the peculiar disposition of the pale corpuscles to adhere to the walls of the vessels. This disposition has been ascribed to a vital attraction; but although it is made subservient to the purposes of life and organization, it appears to me to be the mere result of the physical property of adhesiveness common to soft solids of glutinous material. The same property is shown in the field of the microscope by the pale corpuscles sticking to the glass, whilst the red particles float in the liquid. It has however been objected that in blood drawn from the vessels "the white corpuscles do not show any tendency to adhere to each other or to the red particles, which they naturally would do if their surfaces were adhesive enough to cause them to stick to the walls of the vessels."* This objection has no force when it is considered that the white corpuscles do cohere most readily when brought into contact, and the reason why they appear separate in the field of the microscope, is because they at once stick to the glass and are not free to move and congregate like the red corpuscles. They do not usually adhere to the red corpuscles, because these are smooth, loose sacs of fluid, possessing exosmotic properties which are intended to keep them as loose and free from each other as possible, so that they may be carried with every motion of the current.† But there are circumstances in which the red and pale corpuscles do cohere together; that is when their compression within the vessels prevents exosmosis: so also there is a condition of the walls of the bloodvessels in which the pale corpuscles adhere to them little or not at all; that

* British and Foreign Medical Review, July, 1844, p. 107.

† These physical differences may be rudely illustrated by a clot of adhesive jelly and a thin bladder containing water; the jelly adheres to any plane or concave surface, so that it cannot be detached by inversion; the bladder rolls readily when the surface is inclined, and will not adhere even to the jelly.

is when osmosis through the walls of the corpuscles is as free as exosmosis, in the absence of all distension of the vessel; and this explains why, in the instance before mentioned, the adherent pale corpuscles become detached as the circulation is restored to its natural state.

The ordinary pale corpuscles of the blood certainly have a cell-wall, as described by Gulliver and Addison; but those recently formed in inflamed vessels do not appear to me to be so invested, and hence their more adhesive property. They soon, however, acquire this outer membrane, which seems to be nothing more than a pellicle of coagulated albumen or deutoxide of protein of a more solid consistence than the rest of the corpuscle. Globules of milk, oil, &c., in serum acquire an albuminous coating, in like manner, as observed by Ascherson, Donné, and Gulliver. That much of the process of cell-formation is of a chemical character cannot admit of doubt; but in all probability the future behaviour of the cells thus formed will be determined by their capacity for vital properties of which we know little.

418. Except as the chief vehicles of oxygen, the red corpuscles seem to be less concerned than the white corpuscles, in the commencement of the obstruction of inflamed vessels: the red corpuscles are seen at first free, although twisting and struggling between the accumulating white corpuscles: and so long as they do move along, *they show no disposition to cohere or form rouleaux*: but if the obstruction be increased a little by another white corpuscle or two, so narrowing the path, that the red corpuscles can no longer find a passage, then these also stick, and forced by the current from behind, their flexible and elastic bodies become jammed in such numbers in the interstices of the white corpuscles, that the whole vessel speedily presents an almost homogeneous deep red colour, from the great accumulation of red particles, the liquor sanguinis having filtered through. This is the state of total obstruction, the process of which may be watched when the irritation is extremely gentle; but in most instances this condition is produced so suddenly and extensively that the successive changes involved in it escape observation, and the contents of the vessels appear to become at once stagnant and uniformly red, as if the blood had suddenly coagulated within them. The pale corpuscles are no longer distinctly visible; and therefore their presence has been denied by some observers; but if in any part the current

again forces a passage, some of those corpuscles may be seen adhering to the sides of the vessels.*

We have formerly admitted as probable the influence of osmotic force in promoting and retarding the passage of the blood through the capillaries (§ 295): and as variations in this force were recognised as concerned in the obstruction of congestion, and in the increased flow of determination, it is reasonable to suppose that they obtain also in inflammation, which comprises the conditions of congestion and determination in different parts of the affected vessels. I suppose this osmotic force to depend on certain chemical affinities subsisting between the constituents of the blood and those of the vessels which convey it: and it is quite conceivable that a derangement in these affinities may impair, suspend, and even reverse the motion so far as it arises from this force. But this force is almost if not entirely limited to the capillary vessels, and will be superseded in proportion as these get distended, and the chemical relations between them and their contents become balanced. Very probably therefore this cause of obstruction in the circulation is rather connected with the incipient process of inflammation than with its full development.

419. The foregoing considerations warrant the conclusion that the process of inflammation is essentially more complex as well as further removed from the natural state, than either congestion or determination of blood; that it includes, in fact, both of these conditions together with certain changes in the blood within the

* Mr. Wharton Jones and Mr. Paget, whilst they both question that the pale corpuscles have much share in causing the obstruction of the vessels in inflammation, do not agree as to the condition of the red corpuscles. Mr. Jones states that he has seen these cluster together in rolls within the vessels of a bat's wing under irritation (Med. Chir. Trans., 1853, p. 396); whilst Mr. Paget asserts that "the corpuscles are indeed closely crowded, but they are not clustered, nor do they appear adherent" (Lectures on Surgical Pathology, 1853, vol. i. p. 316). Mr. Gulliver writes to me that he has observed the aggregation of both red and pale corpuscles within the vessels; and he considers that the obstruction of the vessels is mainly due to this. He adds, "this pale cell-formation and dissolution is constant in true phlegmonous inflammation, and is indeed an essential part of it, as I infer from numberless observations on inflamed human parts."

In his latest observations on the wing of the bat, Mr. W. Jones admits that "after the web had been much irritated, he has seen, in the venous radicles especially, colourless corpuscles accumulated in great numbers, as we so often see them in the frog" (*loc. cit.*).

Although, therefore, I am ready to allow that the pale corpuscles may not be so universally or largely concerned in causing the obstruction in the vessels of inflamed parts, as my observations formerly led me to suppose, yet I think that there is ample evidence to prove that they usually have an important share in the inflammatory process, and in contributing to its results.

vessels, and leads to further results more extensive and more varied than those that follow from congestion and determination. There is increased motion or determination of blood to the affected part, with a more or less obstructed flow through it: the force of the increased motion being partly expended on the arterial portions of the obstructed vessels (§ 414) and partly diverted into the collateral channels so abundantly supplied by the anastomosis of vessels (§ 410). The obstruction in the vessels of an inflamed part seems to be due to several circumstances, which probably vary considerably in different forms and degrees of inflammation. Thus in those which begin with congestion (§ 403) the obstruction may depend much on the increased mass of blood in the distended capillaries and the impaired elasticity of their coats (§ 300); and in part also on the diminution of the osmotic force (§ 295) which naturally favours the passage of blood through the capillaries. Changes in the blood probably ensue sooner or later in all instances, and tend to increase the obstruction; but it is where the inflammation originates in direct irritation (§ 402) that the blood in the vessels seems most speedily to become a cause of obstruction, even in opposition to an increased current directed on it through the enlarged arteries; and of these blood-changes, a diminution in the osmotic properties may be one; the formation of pale adhesive granules and compound cells is another; possibly the agglomeration of the red corpuscles may be a third; and the result of this co-operation is that more or fewer of the capillaries are obstructed by a mass of red and white corpuscles so amalgamated as to be no longer distinguishable.

420. The effect of these changes, the essential conditions of inflammation, is, that much of the circulating force conveyed by the arteries is expended on their capillary terminations; the enlargement and tortuosity of these capillaries, the production of corpuscles which adhere to their sides, and their consequent total obstruction by these and the red corpuscles together, seem to be so many several expedients used by nature to direct the force of the circulation to the particular vessels by which the process of reparation and nutrition is chiefly carried on. We have further suggested, that an obvious effect of this local direction or determination of force, is the more free supply of oxygen to the plasma, and that the resulting formation of a solid deutoxide of protein is the probable explanation of the production of the material of those

white corpuscles which augment and complete the obstruction. This leads to the consideration of the further changes effected by inflammation.

421. We have already found that an inflamed part is the seat both of determination, and of congestion or obstruction. It is this combination that leads to the changes which characterize inflammation, and which, in extent and variety, exceed the changes from any other kind of hyperæmia. The determination of blood to the obstructed vessels and to neighbouring parts is attended with the ordinary results of this process (§ 333, &c.); but to a greater extent than usual, because the cause of determination is more permanent. The congestion or stagnation has also its effects (§ 303, &c.); and these too are more marked and peculiar than usual, because the obstruction is more complete than in congestion in general, and because it is modified by the influence of a continued force of blood acting physically and chemically against it, and by the new or increased cell-formation set up in and around the minute vessels. All these circumstances point out that the natural functions of the vessels must be much modified by inflammation, and this in different modes in different parts of the inflamed site. Thus, in the vessels which are the channels of an increased flow, the functions will be more or less exalted or excited; whilst in those that are obstructed, vital properties will be more or less depraved and impaired. It is the approximation of two such opposite conditions, excitement and interruption of living actions almost in the same spot, that renders continued inflammation so seriously destructive to structure as well as to function.

422. Inflammation at first much exalts sensibility (§ 133) and contractility (§ 111); causing tenderness, pain, and spasm. But the obstructed circulation may cause a suspension of these properties (§ 273) in the centre of the mischief, whilst in surrounding parts, the seat of determination, they are exalted. The sympathetic relations (§ 152, 156) of the inflamed part are also commonly affected. Natural secretions are either suspended by inflammation, or altered by the addition to them of various modifications of the serous and albuminous parts of the blood. This involves the change of the nutritive process, which is so important and early a part of inflammation, that it must be noticed more fully. We shall recur to the other effects of inflammation under the head of symptoms.

423. The effusions from inflamed vessels are, at an early period, much the same as those produced by tense congestion (§ 305—8) and determination of blood (§ 340, 1); but they commonly occur in greater abundance, contain more animal, fatty, and saline matter; and, as the inflammation advances, sometimes present appearances not found in cases of mere congestion or determination. Thus the effusion at first is a thin serum, causing swelling in complex textures, accumulating in the dependent parts of serous cavities, or diluting the secretion of the more simple mucous membranes. But soon fibrin is also effused, a part of which may concrete into coagulable lymph, or still remain dissolved, as in the liquor sanguinis. Fatty matter is also present, both in the liquor sanguinis and in coagulated fibrin: it is visible under the microscope in the form of molecules, separate and aggregated.* Thus an inflamed pleura becomes coated with a film of lymph; and the clear fluid effused into the sac, when removed from the body, sometimes spontaneously separates into a fibrinous clot and serum. When this occurs in complex textures a hardness is given to the swelling, as in phlegmon of cellular membrane, hepatization of the lung, &c. In mucous membranes, there may be thickening of the submucous texture, and the mucous secretion often becomes unusually viscid. The salt taste of the expectoration in the early stage of bronchitis denotes the increase of saline matter in it. The presence of the chlorides in the substance of an inflamed lung has been shown by Dr. L. Beale to correspond with their absence from the urine in pneumonia. Thus the inflamed vessels seem to acquire for the time a new excretory action.

424. The microscope has supplied much detailed and precise information regarding the nature of inflammatory effusions, although further research is yet needed, into their varieties and relations to each other. In the frog's web, after inflammation has continued some hours, there appear outside of the vessels, (especially where the strongest current encounters the most complete obstruction), white globules or corpuscles, with specks in them, exactly like the pale granular globules within the vessels (§ 415). These are found in most kinds of inflammatory effusions, and are called *exudation corpuscles, granule cells,* or *fibrinous globules.* Mandl supposes them to be merely consolidated globules of fibrin, and states, that the liquor sanguinis may be seen to coagulate in similar glo-

* These were first described by Mr. Gulliver (Med. Chir. Trans., vol. xxvi).

coagulated albumen, or completely amorphous and homogeneous (Vogel), *hyaline* of Gerber. Now, some or all of these conditions are presented in inflammatory effusions, but they occur in very various proportions, and in different modifications, as will be specified hereafter. In the following summary of the elementary solids of inflammatory effusions I am indebted to my friend, Mr. Gulliver, for several suggestions and corrections.

1. *Molecules,* of extreme minuteness, from $\frac{1}{35000}$ to $\frac{1}{8000}$ of an inch in diameter; smooth and apparently spherical; composed of fatty matter, oleine (Davy and Gulliver), (*smaller primitive molecules;* Gruby, minute free cell-seeds; Gulliver.)

2. *Granules* (Gerber, Addison, Henle; *larger primitive molecules,* Gruby), measuring from $\frac{1}{12000}$ to $\frac{1}{8000}$ of an inch; appearing as a light spot surrounded by a dark circle; probably consisting of a film of albumen or deutoxide of protein investing a central molecule of fat.

3. Fibrils, extremely fine; interlaced and decussating; the same as those seen in the buffy coat of the blood and other concrete fibrin. Larger fibres, swelled and nucleated at the centre, and tapering off at the extremities, are also sometimes met with.

4. *Exudation corpuscles, compound granules, granular cells, aggregation corpuscles, cytoid bodies,* "of an average diameter of $\frac{1}{1400}$ of an inch; pale or dark in transmitted light, according to their density, or more or less of the aggregation of their component parts, which are chiefly *molecules* (1), either merely coherent in

* Lancet, 1838.

† Note to Gerber's General Anatomy, p. 31, and Introduction to Hewson's Works, p. 45.

‡ Med. Gaz., April 15, 1841.

rounded or oval masses, or connected by minute granular matter, sometimes with a delicate investing cell-membrane" (Gulliver). Being chiefly made up of molecules and granules, they consist of fat and concrete albumen or protein.

5. *Pus globules,* "of an average diameter of $\frac{1}{2666}$ of an inch, and therefore smaller than the exudation corpuscles" (Gulliver). They are also more essentially and distinctly cells, containing liquid, with more or fewer granules, some of which are larger than the rest, and are called nuclei. The cell-membrane consists of protein, which with fat also forms the granules.

6. Irregular granular, flaky, and hyaline matter; the former, consisting of protein and fat; the latter albuminous also, with filamentous matter resembling fibrin, but chemically different. These constitute the chief materials of tuberculous and other cacoplastic and aplastic deposits. They often exhibit traces of cells and fibres, and sometimes numerous small cells, but of an imperfectly formed or degenerated kind.

In addition to the above, inflammatory effusions generally contain the solids natural to the part, such as mucous globules, epithelium scales, epidermis, and also blood corpuscles.

425. Of these elementary solids of effusion, the fibrils certainly form from liquor sanguinis when out of the vessels, and even after its removal from the body (Addison and Gulliver); but it is a question whether the other varieties concrete spontaneously from the liquid fibrin, or grow from germs, (molecules or granules,) that are disseminated from the vessels or adjoining textures. The close resemblance of the exudation corpuscles and their contents to the white globules and granules so abundantly produced in the blood of the inflamed vessels, would seem to indicate that these bodies are identical; but it is not easy to understand how such can pass through the walls of vessels, in which no pores are visible under the highest magnifying powers. Mr. Addison has, indeed, represented the white globules as first passing into the substance of the wall of the bloodvessel, and then being thrown out from it; but this would seem too slow a process. It would appear more probable either that nuclei or molecules, too small to be discernible, do pass out through the wall, and then grow into compound granules (granular exudation and pus corpuscles); or that the corpuscles themselves are formed by coagulation in the effused liquor sanguinis as the fibres of fibrin certainly are.

426. These solid products of inflammation are the materials out of which new membranes, textures, and deposits are formed; and present every variety of much, little, or no plasticity or capacity of organization, from that of perfect cicatrices and false membranes, down to that of yellow tuberculous matter.* As we shall have to notice these further when speaking of results of inflammation, we shall now pass on to consider the further consequences and symptoms of inflammation.

427. Inflammation is always attended with more or less effusion. When the inflammation is slight, this effusion may remove it by unloading the engorged bloodvessels: but where the inflammation is more intense, that is, where the obstruction is considerable and the determination of blood strong, the effusion may go on to a great extent without resolving the inflammation. It is then that the more serious effects of inflammation result. The effused matters press on and pervade the adjoining textures, derange their nutrition, and impair their cohesion; and thus takes place that *softening* of textures, which occurs chiefly in such complex structures as retain the effused matter. The continued obstruction in the inflamed part leaves the veins and lymphatics free to absorb, and the high pressure and determination of blood tend rather to promote this process of absorption. Hence, as new matters are effused, the old texture is compressed, disintegrated, and absorbed; the finer exudation corpuscles and fibres are removed or altered, and the large pus globules alone remain and accumulate: this is *suppuration.* Or if the original obstruction of the inflamed vessels be extensive, or have been rendered so by the subsequent effusion, the supply of blood may be so stopped in a part, that it dies, and the dead part may then either be only dissolved and absorbed where it is connected with the living textures, and thus be separated in form of a *slough;* or if the obstruction be yet more extensive, the dead part may pass into decomposition before it can be separated; thus occur *gangrene* and *sphacelus.* If the inflammation be of a lower kind, the obstruction less complete, and the

* This statement, which is in accordance with the observations of the most esteemed pathologists of the present day, very nearly corresponds with the views which I published more than a quarter of a century ago, at a time at which, and long after which, pus and tubercle were considered to be matters *sui generis*, of nature and origin totally different from coagulable lymph. They always appeared to me to be only modifications of the plastic material of the blood, presented in different conditions, and this seems now to be the commonly received opinion.

effusion more gradual, the nutrition of the natural texture is only impaired, not arrested, and from the increased deposition of solid matter, *induration* or *consolidation* takes place.

SYMPTOMS AND EFFECTS OF INFLAMMATION.

428. We have now described the process of inflammation in its intimate nature and phenomena; we have next to notice its more obvious effects on function and structure, which indeed are the *symptoms* of its existence. These symptoms may be divided into *local* and *general;* the local occurring chiefly in the part which is the seat of inflammation; the general affecting the system at large.

LOCAL SYMPTOMS.

429. We have before stated that the local symptoms are commonly more marked, and earlier in order of occurrence if the inflammation be excited by local irritation (§ 402); the fever which afterwards supervenes may disguise the local symptoms. The chief local symptoms have been already mentioned in the definition, *redness, heat, pain, and swelling,* but to these must be added various disturbances of the function of the part affected. We go on to explain and illustrate these symptoms.

430. The *redness* of an inflamed part is obviously due to the increased quantity of blood in its vessels. These vessels are all much enlarged, so that they receive many more red corpuscles than usual; the finest capillaries, which commonly are invisible from admitting only the liquor sanguinis, and a row of one or two red corpuscles, are now distinctly coloured from the number of these bodies that pass into them. The enlargement is not uniform; some vessels are elongated and tortuous, as well as distended; others are varicose or saccular, as was first described by Mr. Kiernan, and more recently by Kolliker and Mr. Paget. Some observers have thought that new vessels are formed by the blood forcing its way through the textures. I have never seen this in the frog's web, and Mr. Paget denies its occurrence in any case except in inflammatory lymph; but it has been said to take place in some textures which are not naturally vascular, such as the anterior part of the cornea, and cellular cartilage (Toynbee). But the microscope shows that the redness of inflammation arises from the stagnation

of blood in the vessels, as well as from the entrance of numerous red corpuscles into capillaries that do not ordinarily contain them. The colour of inflamed parts is much more red than is that of parts simply congested, or through which a current still passes; this has before been referred to the accumulation of the red corpuscles which then takes place (§ 415, 417, *note*): this crowding of the red corpuscles has also been recently noticed by Mr. Paget (Lectures, vol. i. p. 296). The obstructed vessels appear so impacted with colouring matter to their outmost limits, that the shape of the blood discs and of the white corpuscles is no longer discernible: yet these are still often present; for when an obstructed vessel re-opens, the red mass breaks up into clots and particles, and in many instances white corpuscles are left sticking to its walls. (See *note*, § 416.) It is obvious, therefore, that the obstructed vessels become stuffed, as it were, with red as well as white corpuscles, which cause a brighter and stronger red than that produced in mere congestion. In many instances, too, it may be seen that the redness of an inflamed part is augmented in spots and patches where blood is extravasated; this happens especially in some varieties of inflammation.

The redness of inflammation presents great modifications according to the number and distribution of the vessels of the part; but its most essential seat being in the capillaries, its most constant character is a diffused or capilliform redness. This is commonly far more vivid and general in the living than in the dead body. In the skin and mucous membranes during life, it is often seen as a uniform blush of colour, varying from a delicate pink to a bright crimson. After death this blush has sometimes entirely disappeared; but commonly more or less of it remains; and on examination with a lens, it is found to consist chiefly of numerous vascular striæ, meshes, or points, with here and there larger vessels and ramifications also injected. But the large venous vessels are distended much less generally than in congestion (§ 280), and the redness is therefore less arborescent and ramiform. To explain the reason of the disappearance of inflammatory redness after death, we must bear in mind that much of the colour depends on determination of blood (§ 326) which is maintained by the action of the heart, distributed through the arteries; and that when this force ceases in death, the tonic contraction of the arteries, which survives for a few hours, perhaps aided by osmotic force (§ 295), expels the blood

from the vessels (§ 120). A similar effect is sometimes produced during life, by cardiac syncope. The redness that remains after death seems chiefly to depend on the vessels which have become totally obstructed and impacted with blood, or which have been long congested and have lost their tone (§ 295). This furnishes a useful means of distinguishing the comparative prevalence of the several elements of inflammation in different cases. Thus when the redness disappears after death, we know that the predominant condition was local determination of blood (§ 409) without much obstruction or permanent congestion. This is observed in erythematic and diffused membranous inflammations, the cutaneous inflammations of eruptive fevers, and the early stages of all inflammatory action excited by moderate local irritation (§ 402, 415). On the other hand, if much redness remains after death, it may be inferred that obstruction or congestion of the vessels has existed to a great extent. This happens especially in phlegmonous inflammations, those of parenchymatous tissue, those which have advanced to a certain high degree of intensity, and those which have originated in congestion (§ 403).

The florid hue of the redness is also during life a sign of the predominance of determination, for it shows that the blood is chiefly arterial and not stagnant. Where congestion prevails, or where the blood has been long stagnant in many vessels, the colour is deeper; but it is rarely so deep as in pure congestion, for the presence of white globules tends to lighten it or give it a florid tinge, and it is probable that the red corpuscles stagnant in the vessels, still receive oxygen from the communicating arteries, which are the seats of determination of blood. In the dead body these distinctions are not equally available, for the arterial part of the blood may have been removed by the contraction of the vessels, or darkened by stagnation; and the livid portions speedily become florid on exposure to the air.*

The progress of inflammation modifies the redness. The colour becomes more florid and deeper as the inflammation advances to its acme; it then becomes either livid before it subsides, or paler from the presence of effused matters. In complex textures,

* I have often in the dead-house seen mere congestive redness mistaken for inflammatory, because it was florid, from the action of the air, or from the translucence of a subjacent white structure. Frequently, too, the claret stain of arteries and intestines is mistaken for inflammatory redness; a common lens will prove it to be not so, by showing that it is not vascular.

effused lymph or pus often changes the redness to pink, flesh colour, drab, or yellow.

431. The *heat* of inflammation is obviously dependent on the increased flow of blood to, and through, the part; and it may be considered to represent the amount of determination of blood concerned in the inflammation. Hence it is great in extensive and active inflammation, and is generally proportioned to the florid redness or arterial vascularity. It is not certain whether the high temperature of an inflamed part is caused by the augmented changes going on in that part, or whether it arises merely from the greater quantity of warm blood which passes through it. John Hunter made some observations to determine this point, and never found that the temperature of an inflamed part was raised above that of the interior of the body, which it might be expected to be if inflammation was in itself a calorific process. That extensive inflammation raises the heat of the whole body, as well as of its own site, is quite certain; but this may be simply by causing general excitement, especially of the circulation and respiration, and by repressing the perspiration and other exhalations, by which the body is naturally cooled. It seems, however, quite consistent with analogy to admit that inflammation, as a process of increased vascular action, may generate heat; and inasmuch as there is an augmentation of the red corpuscles in the part, which are supposed to be chief agents in the generation of heat (through the oxygen which they supply), we see a reason why the calorific process may be exalted in the inflamed part. Increased heat is a very important and valuable symptom of inflammation, since it is more constantly discernible than any other, and serves to distinguish inflammation from congestion and nervous irritation, which may resemble it in other points. But to indicate inflammation the heat must be continued, and not merely come in flushes of simple determination of blood. Generally the skin is dry as well as hot: but it may be perspiring, and yet a temperature, higher than natural, may be sustained.

432. The *swelling* of an inflamed part is caused in some degree by the enlargement of the vessels, but chiefly by the effusions from them, and it will be therefore proportioned to the amount of these; but the situation, form, and degree of the swelling will also greatly depend on the natural structure of the part inflamed. In serous membranes, the vessels being comparatively few, admit

of but little enlargement; and the effusions, not being retained by complexity of structure, soon overflow externally and accumulate in the most dependent parts of the serous sacs, causing dulness on percussion, and sometimes fluctuation in the chest and abdomen, and when in large quantity distending their cavities. Mucous membranes are more vascular and complex in structure: hence the early enlargement of vessels causes some thickening; but the swelling is chiefly due to interstitial effusion in the submucous tissue (so manifest in coryza and cynanche): this effusion, when merely serous, soon passes off in the thin flux which attends catarrhal inflammations, and the swelling may subside with it: when the effusion is more solid, the swelling remains longer, is attended with a more viscid secretion, and subsides only when this secretion becomes opaque, and somewhat fat in its composition. The skin presents great variety in the swelling as well as in the redness caused by inflammation. Sometimes the swelling is diffused and hard, as in cutaneous erysipelas. In urticaria the same kind of hard swelling occurs in spots or patches, and in places the effusion supersedes the vascular redness, causing white centres or wheals. In tubercular inflammations of the skin the redness and swelling are still more circumscribed, and the effusion seems to be chiefly solid. In papulæ the swelling is even more restricted, and confined to a point. In blebs and vesicles, the effusion is between the cuticle and the true skin, and the swelling is confined to corresponding patches or small spots. Inflammation of cellular texture is attended with considerable swelling; which is diffused, œdematous, and pitting on pressure when the effusion is serous; more tense when there is fibrin with the serum: and hard and circumscribed (as in phlegmon) when the matter effused is chiefly fibrin. Parenchymatous organs, in like manner, are remarkably swelled by inflammation. The liver, kidneys, testicles, lymphatic and other glands, attain a large size from the mere distension of their bloodvessels; and we have noticed a similar result from mere congestion (§ 293); but still more inflammation does not continue long in these structures without causing effusion, which may constitute swelling, varying in its firmness according to the proportions of serum and lymph thrown out, and to the resistance of their investing membranes. The lungs, from their porous structure, do not swell much in bulk; but the effusion displaces the air in their cells, thus increasing their weight, and if the effu-

sion abound in lymph, converts them into a more or less solid liver-like mass (hepatization).

433. The *pain* of inflammation results from that exaltation of sensibility (§ 135) which determination of blood produces (§ 333), and from the tension or pressure arising from the swelling. The amount of pain will therefore depend much on the natural sensibility of the part, the degree in which determination of blood predominates, and the tension or pressure induced. The severest pain arises where all these circumstances co-operate, as in inflammation of the pulp of a tooth, the sheath of a nerve, or the lining of a bony canal, like the auditory meatus, &c. In other cases pain is chiefly felt when the inflamed part is pressed or stretched, constituting excessive tenderness. Thus the pain of peritonitis is felt when the abdomen is compressed, or when its walls are strained by coughing or vomiting; the stitch of pleurisy is perceived on taking a full breath: the pain of external inflammation and rheumatism, on motion or pressure on the limbs. In enteritis there is often little pain until the intestines become spasmodically contracted in some parts, and distended in others, by flatus and other contents: the pain may vary, whilst the inflammation remains the same. Parenchymatous organs and mucous membranes being comparatively soft and yielding in texture, are not the seat of much pain, when inflamed. In the early stage, pain, with heat, may indicate the activity of inflammation, that is, the prevalence of determination of blood. In the more advanced stages, the pain rather bears relation to the amount of tension from swelling or effusion, and is commonly relieved when these become more diffused, or end in suppuration.

434. Besides pain and tenderness, sensibility increased by inflammation sometimes exhibits other modifications, such as feelings of soreness, tingling, heat, itching, &c. Peculiar sensations are also excited in the organs of special sense when they are inflamed, such as noises in the ears, painful and disturbed vision, &c. The peculiar sensibility which excites the motions of sneezing, coughing, vomiting, micturition, and defæcation, is exalted, when the Schneiderian membrane, the lining of the upper part of the air-tube, the cardiac end of the stomach, the bladder, and the rectum, are respectively inflamed. Other sympathetic sensations (§ 156) excited by inflammation are peculiar to disease, as the pain in the shoulder-blade, with inflammation of the liver; pain in the

testicle, with inflammation of the kidney; pain of the glans penis, in inflammation of the bladder; pain of the knee, with inflammation of the hip.

435. Contractile fibre is not itself prone to inflammation; when the parts contiguous to it are inflamed, the effect is commonly first to increase its irritability (§ 113), and subsequently to impair it, probably by exhaustion. Thus the heart, when its membranes are inflamed, acts first with great force and frequency, but subsequently with feebleness and irregularity. When the intestines, bladder, or air-tubes are inflamed, there is contraction followed afterwards by more or less weakness of the muscular fibres of these parts.

436. Other functions are somewhat similarly affected under the influence of inflammation. In inflammation of the brain and its membranes, there is commonly at first more or less excitement of the sensorial powers, leading to delirium, hallucinations, and convulsions; afterwards stupor, coma, and paralysis ensue. In the early stage of inflammation of the spinal cord, there may be tetanic convulsions; afterwards follows paralysis. Often symptoms of partial excitement are conjoined with others of interruption of function; and this is not extraordinary, seeing that inflammation comprises diminished as well as increased flow of blood, and that the former generally predominates as the inflammation advances and effusion proceeds. Inflammation of the lungs causes dyspnœa: that of the stomach interferes with digestion: inflammation of the kidneys suspends or impairs their secreting power, &c. Further details belong to special pathology.

CONSTITUTIONAL SYMPTOMS OF INFLAMMATION.

437. The irritation of inflammation frequently extends itself to the system at large. The functions of the whole body are more or less disordered. The contractions of the heart are more frequent and forcible than usual: the arterial tonicity is increased (§ 121); hence the pulse is quick and hard: the skin is dry and hot: the appetite and strength are impaired: and the natural secretions are diminished and otherwise disordered. This is *inflammatory fever.*

438. Among the most important general effects of inflammation must be noticed the change in the condition of the whole blood.

We have before noticed, that there is an excess of fibrin and of the colourless globules in the blood in inflammatory diseases (§ 195); and that the separation and contraction of this fibrin (§ 203, 4) take place in an unusual degree, and produce the peculiar buffed and cupped appearance of the clot so remarkable in inflamed blood (§ 208). This excess and separation of fibrin displayed in the buffy coat is commonly proportioned to the extent of the inflammation and its duration in an active state. This suggests the view that the change in the blood is altogether produced in the bloodvessels in and near the inflamed part: and that increased development of white globules, sometimes seen by aid of the microscope (§ 415), is a kind of demonstration of this production. This supposition derives support from the fact, that blood drawn directly from an inflamed part is more buffed than that drawn from a distant part.* The excess and separation of fibrin is more remarkable in inflammations of serous membranes than in those of mucous membranes, or parenchymata, which may perhaps be ascribed to the former inflammations being attended with less local vascular distension and effusion of the exudation corpuscles and fibrin. Acute rheumatism presents in the highest degree, the buffing and cupping of the blood; perhaps because the inflammatory irritation arising from the presence of offending matters in the blood itself† (§ 251) affects a great many vessels, yet without completely obstructing them, so that then determination of blood predominates over congestion: although there may be much inflammation and effusion of the early kind (§ 423), this does not lead to suppuration, or other of the more destructive changes which follow inflammation. It has been before mentioned (§ 245), that an increased activity of circulation and respiration might contribute to augment the fibrin of the blood in acute rheumatism and in other inflammations not impairing the respiratory function; but it was then objected, that the increase of the fibrin is sometimes observed in rheumatism where there was not much acceleration of the pulse and breathing; and, on the other hand, in fevers in which the pulse and breathing are much hurried, the fibrin of the blood is even diminished (§ 196). It was found, by Andral

* I have observed this even in blood drawn by cupping, on a part inflamed by the previous application of a blister.

† The buffed appearance of the blood in inflammatory dropsy admits of a similar interpretation (§ 385).

and Gavarret, that in fevers, the occurrence of local inflammation always caused an increase of the fibrin in the blood.

It seems pretty clear, then, that the increase of fibrin, and the exaltation of its contractile and separating qualities originate in the vessels of the inflamed part, and must be regarded as an augmentation of one of the processes of nutrition effected by inflammation. A similar augmentation takes place in the vessels of the uterus during the latter months of pregnancy, when the blood drawn generally exhibits a buffed appearance; and although the same appearance is not commonly presented by blood drawn from fast-growing children during health, yet in them it is very readily induced by inflammation, and the plastic products are then unusually copious. In young pulpy growing parts the pale corpuscles are very abundant, and Mr. Gulliver long since applied to them the term "embryo flesh and blood." (Tr. of Wagner's Physiology, p. 251.) It has been mentioned (§ 415), that in young frogs even in health, many white globules are seen in the bloodvessels adhering to or moving slowly along their sides; and this appears to be a proof that it is the same nutritive or plastic process, which is exalted to its highest degree in acute inflammation.

439. It has been supposed that the hyperfibrinous state of the blood is the cause of the general excitement constituting the symptomatic fever accompanying inflammation; but it must be remarked that this fever frequently rises high before the blood has begun to exhibit the buffy coat, that it often subsides when the buffy coat is most abundant, and that it is sometimes wholly absent when the blood is both buffed and cupped, as in subacute rheumatism. It is very probable, however, that the excess of fibrin may contribute to the excitement; it certainly materially affects the duration and products of the inflammation.

440. In inquiring into the pathology of inflammatory fever, we must bear in mind, that it sometimes precedes the distinct development of the local inflammation, being in fact a general excitement or reaction, immediately induced by the influence of the exciting cause. This is especially the case where inflammations are produced by cold, fatigue, and other causes, which first induce congestion (§ 403). The operation of these influences, is at first depressing to the whole system; this is marked in the cold stage of the fever, where there is weak pulse, coldness of the extremities and surface, general pallor, chilly and various uneasy feelings,

dejection of spirits, and depression of strength. Afterwards ensues the reaction, beginning with rigors, accelerated pulse and breathing, sometimes vomiting, and other signs of functional disturbance: the skin then becomes hot, the pulse hard, as well as frequent; uneasy feeling in the head, back, and limbs are experienced, as well as thirst, loss of appetite, restlessness, and much weakness. Now it is during, or after the establishment of, this reaction that the local symptoms of inflammation become prominent. During the cold stage there may have been congestion of the affected organ (§ 303), impaired function, and more or less uneasiness; but now pain (§ 433), heat (§ 431), and various symptoms of local irritation (§ 434), appear; and frequently, as these become developed, the general disturbance is somewhat reduced or modified. In eruptive fevers, the general disturbance and functional disorder is nearly always greatest before the eruption (or local inflammation) occurs. In inflammations resulting from cold or fatigue, the first disorder is often very like continued fever, but this becomes simple inflammatory fever as soon as the inflammation is pronounced. In other cases, again (chiefly such as originate in local irritation), (§ 402), the inflammation is developed, and its symptoms are prominent, before the symptomatic fever is excited. Generally, however, the fever is in proportion to the severity or active character of the inflammation; if it were always so, we might conclude that it was simply the result of a reaction from the disturbance of the circulation produced by the inflammation; but we sometimes find inflammation of trifling organs, such as the tonsils, attended with a very smart fever; and much greater disturbances of the circulation, such as congestions of the lungs and liver, without any fever at all. It seems more probable, then, that the fever accompanying inflammation arising from local irritation, is caused by an influence that is propagated from the inflamed part to the heart and arteries through the medium of the nerves. The same influence also probably sustains the inflammatory fever, in the cases before noticed in this paragraph, where the first febrile movement seems to be clearly the result of reaction. In fact it seems now to be a growing opinion that febrile heat is more or less directly dependent on derangement of functions of the nervous system, especially the sympathetic nerves which have immediate influence on the heart, bloodvessels, and respiratory apparatus. The experiments of Bernard and others seem to show that injury

to these nerves causes an increased action of the heart, enlargement of the vessels, and an augmentation of heat—in short the phenomena of fever: and it is assumed by Virchow as an inevitable inference that fever is the result of increased change in the tissues under the immediate influence of a modified condition of the nervous system.

441. It still remains unexplained why, in fever, the circulation and some other of the vital functions are excited, whilst others, such as secretion, muscular energy, and the appetites, are much impaired. We may partly solve this difficulty, by bearing in mind the fact that the excitement is not one of a healthy kind; it is attended with an excessive tonicity of the arteries (§ 121), which is the cause of the hardness of the pulse, and which may transmit the blood through the capillaries too rapidly to permit of its undergoing the proper changes by excretion. It is also possible that the secreting powers (§ 158) may be even more directly impaired by the inflammation, or its cause; for it is certain that, either as cause or effect, imperfect secretion is one of the most prominent features of fever in general. The bowels are generally costive; the urine scanty and high coloured; the skin dry; and the tongue clammy; ulcers or sores also, that have been discharging before, often become dried up. And so, again, on the subsidence of the fever, all these secretions are restored.

Finally, we may sum up the causes of the symptomatic fever of inflammation as being comprised under three heads:—1. Reaction after the depression induced by some such influences as cold, fatigue, &c. 2. Irritation communicated to the heart from the seat of inflammation, probably through the nerves; this acts most powerfully in irritable constitutions. 3. The altered condition of the blood, consisting in an excess of fibrin, and a retention of excrementitious matter; this especially sustains the fever.

442. The fever accompanying inflammation is generally *high*—that is attended with hard pulse, hot skin, and general excitement—in the young, the sanguine (§ 38), and plethoric (§ 279); those, in short, in whom the vascular system is naturally active (§ 401). On the other hand, it is commonly *low*—that is, with weaker, though sharp and quick pulse, less general heat of skin, and with tongue more foul, and functions rather oppressed or disordered than excited—in persons of phlegmatic temperament (§ 40), and in those who are weak from age, disease, malnutrition, intem-

perance, or undue confinement. The type or character of the fever also varies with the seat of the inflammation, and the particular textures affected, although the variation is less constant than it is generally represented to be. It is commonly stated, that the fever is high in inflammations of serous and fibrous textures, and in phlegmonous inflammation of cellular texture; that it is low in inflammation of the stomach and intestines, kidneys, large joints, and in diffuse inflammation of cellular texture; and that it is of an intermediate character in inflammation of mucous membranes and parenchymatous structures. Clinical experience however shows that there are many exceptions to these statements; and where the type of the fever is affected by the texture, it is chiefly shown in the intensity of the inflammation, and the nature of its result. Diffused inflammations, of slight intensity, often excite very little fever, and cause few local symptoms. The reverse is the case with very acute inflammations even of moderate extent.

443. The nature of the exciting cause, or some co-operating influence, often materially affects the type of the fever. The inflammation occurring after serious accidents or burns is often attended with a low fever, the reaction being imperfect from the continued depressing influence of the cause. The same remark is applicable to the case of inflammation from poisons, which are locally irritant, but sedative to the system. Even the long operation of cold may so depress the vital powers—especially of the heart (§ 75)—that the reaction is imperfect, and the fever low; in all these cases the symptomatic fever is typhoid or adynamic (§ 25), with weak and unequal as well as frequent pulse, varying heat of skin (often with partial sweats); a much furred, or dry and brown tongue; extreme depression of strength; low delirium, and other signs of nervous depression. These symptoms are indications of a disordered state of the blood resembling that induced by morbid poisons (§ 186, 191); and their occurrence receives an adequate explanation when the want of purification and elimination, from which the blood suffers in its congested and imperfectly circulated state, is considered; the evidence of the disordered condition is afforded in the altered state of the blood corpuscles, the presence of urea, and signs of incipient decomposition which may be discovered in the blood, especially in cases of typhoid pneumonia (§ 25).

444. In the lower forms of inflammation (§ 442), the fever may

be remittent or even intermittent: a state of depression alternating with a state of excitement, ending with perspiration; and when inflammation becomes chronic, or is of slight character, it may excite no fever at all. It generally, however, induces some constitutional disorder, in which defective excretion (§ 171) is an important element. When it is borne in mind that inflammation includes in itself determination of blood, it will be obvious that, besides the irritation connected with it, there may be more or less exhaustion of other parts of the body (§ 331): the part inflamed being over-supplied with blood, other parts are in want. This effect is most obvious in anæmic and debilitated subjects; and to it must be ascribed the weak circulation, coldness, disordered functions, and gradual emaciation of the body in general, which are seen when a part suffers long from low inflammation. The blood itself also soon becomes impoverished in continued inflammation, losing progressively its proper amount of red corpuscles, and the fibrin is deprived of its organisable character, and degenerates into cacoplastic or aplastic matter.

NATURE AND SYMPTOMS OF THE TERMINATIONS OR RESULTS OF INFLAMMATION.

445. The results or events of inflammation may be comprehended under four heads: *Resolution, Effusion,* (including adhesion,) *Suppuration,* (including ulceration,) and *Gangrene.* It must not be supposed that these often occur quite singly, or that they are separated from each other by a very marked line; but these terms are conveniently attached to results in which one or the other predominates.

Resolution consists in the cessation of the inflammation, and the speedy removal of any effusion that may have occurred. As inflammation consists of determination of blood, with obstruction to its flow through some vessels; so the resolution of inflammation consists in the yielding of the obstruction and the subsidence of the determination, the dilated vessels contracting to their normal dimensions. This may be well seen under the microscope. Sometimes nothing remains of the inflammation but more or fewer of the white globules adhering to the sides of the vessels; but more commonly some vessels are observed to be still obstructed,

and others congested, with the motion in them slower than usual, the determination of blood (enlargement of the arteries) having ceased. So, commonly, we find congestion remain in a part that has been inflamed; and not unfrequently a flux or watery effusion results from that congestion (§ 375).

446. Resolution of inflammation may occur spontaneously in slight cases; or in consequence of treatment; or from the inflammation being transferred to another part. Some inflammations creep to adjoining parts, as in the case of erysipelas and some other cutaneous eruptions. Others affect similar textures in different parts of the body; and being resolved in one part, appear in another: this happens in rheumatism, which attacks fibrous textures, and is transferred from limb to limb, or joint to joint, by what is called metastasis, or translation. This may be fairly traced to the mobility of the peculiar *materies morbi*, (§ 402,) the cause of the inflammation. A remarkable metastasis of resolving inflammation is sometimes seen in parotitis, the breast or the testicle becoming the seat of the new attack.

447. The occurrence of resolution is marked by a subsidence of the chief symptoms of inflammation: first, of the heat and pain, and, more gradually, of the redness and swelling. The heat usually yields to perspiration. The pain becomes gradually easier; and in some parts, as the skin, may pass into itching before it subsides. The redness sometimes simply fades; more commonly it becomes less florid, and may pass through shades of a livid or dusky hue before it vanishes. The swelling soon subsides: the effused fluids being so speedily removed by absorption, that effusion can scarcely be said to have been a result. Still, in some instances, congestion, or some of its results (§ 274, 350), or nervous irritation (§ 126, 152), remains behind after the inflammation has ceased.

448. The resolution of any considerable inflammation is marked by a reduction of the fever: the pulse becoming softer and less frequent; the skin moist with perspiration, sometimes profuse; the urine, becoming more copious, abounding in urea, and depositing, as it cools, a plentiful lateritious or branny sediment, consisting of lithate of ammonia. The constancy of this last change on the decline of inflammatory fever has led to the supposition that it is critical, and determines the removal of the disease. The lateritious sediment in the urine is a pretty certain symptom of the subsidence of fever, and the amelioration at

least of the inflammation which excited it; but it is uncertain how far it is the cause, or the effect, of the improvement. It indicates an increased excretion of the solid constituents of urine; for there is often an excess of urea and saline matter as well as of the lithates; and comparing this with the scanty secretion of urine during the febrile excitement, and the decay of tissues and blood which is always taking place (§ 254), we can scarcely avoid the conclusion that these excrementitious matters had been accumulated in the blood in consequence of the impaired function of the kidneys during the fever; and that now, as the fever subsides, and their function is restored, the accumulated matter is thrown off. Now, although the function of the kidney must be first impaired to cause the accumulation of the excrementitious matter in the blood, still the matter so retained tends to keep up the disorder (§ 68, 171); hence it is by remedies, which promote the elimination of this matter, that we succeed best in reducing febrile excitement. So, likewise, in cases where the function of the kidneys is permanently impaired by Bright's disease (congestive degeneration, § 309), inflammatory and other fevers are not readily brought to a termination: persons so affected are said to be "bad subjects," with "broken down constitutions;" and they often sink because their excreting organs are unequal to the increased task thrown on them. In cases in which the resolution of the inflammation is only partial or imperfect, a daily remission or alleviation of the fever may take place; and with it there is usually a deposit in the urine, of a pinker or lighter colour than the usual brown lateritious sediment, and containing, besides lithate of ammonia, purpurate of ammonia and lithate of soda. During the resolution of pneumonia the chlorides, which had disappeared from the urine, are again secreted in increased quantity.

Effusion (*including adhesion*).

449. Effusion is a frequent result of inflammation (§ 423); but it is not always a termination of the process, like resolution (§ 427). An abundant effusion of liquor sanguinis, of coagulable lymph and serum, of pus, or of inflammatory mucus, usually lowers the inflammation—that is, reduces the determination of blood, and it may even diminish the obstruction, but often does not remove it; the effused matter then causes sundry mischievous

effects, by compressing, stuffing, or obstructing the several structures in which it accumulates. We may with advantage pursue the history of effusions, by tracing the changes they cause in the chief elementary tissues.

Serous membranes, being simple in structure, afford the best preliminary illustration. In acute inflammation in a healthy subject, besides serum, an exudation of fibrin or coagulable lymph takes place in a few hours. This fibrin is at first in a semi-fluid, ductile state; so that the motion or pressure of the inflamed surfaces draws it into the bands or threads, which exhibit the same adhesive properties that have been spoken of as belonging to one of its constituents, the pale corpuscles, while still within the vessels (§ 417); or it spreads it into films, such as are found on the pleura, pericardium, and peritoneum. But if we examine inflamed surfaces which are less exposed to motion or pressure, as the looser parts of the auricles of the heart, the serous covering of interlobar divisions of the lungs, that of the less projecting parts of the intestines, and that of the convolutions of the brain, we find the deposit of lymph to be not in a uniform film, but in points constituting a granular surface; this shows either that more is effused at some points than at others, or that the concretion of fibrin having begun in points, has chiefly augmented around the same. The granules thus deposited vary in size, from that of a grain of sand to that of a millet-seed; but if the deposit increases, they enlarge into patches, which may run into one another, and even form a continuous mammillated coating of lymph. Even on surfaces which are subject to motion, the predominant deposit of the fibrinous effusion at points is shown by a villous or shaggy appearance of the lymph: this is caused by the lymph in its ductile state, being drawn into threads projecting from the points where it has first concreted: this is sometimes well seen on the pericardium. On the pleura, these inequalities are more obliterated by the rubbing motion of respiration, or by the pressure of liquid effusion.

450. The lymph thus effused is (like the buffy coat of inflammatory blood) at first transparent; afterwards it becomes yellowish, and more or less opaque, but in inflammation of a healthy subject it generally retains some degree of translucency. In this respect, it contrasts with the product of inflammation in unhealthy subjects, (purulent and tuberculous lymph,) which is more opaque.

This difference has been more fully shown by Mr. Paget to depend on the respective prevalence of the fibrinous element in the healthier lymph, and the corpuscular element in the opaque and less plastic lymph: and he distinguishes especially these varieties as *fibrinous* and *corpuscular*. But the most important character of healthy lymph is its high susceptibility of organization, a character which I propose to designate by the term *euplastic* (§ 211). Euplastic lymph consists of fibrils of fibrin crossing each other in various ways, with a moderate intermixture of exudation corpuscles, both compound (cells with nuclei and granules) and simple (granules and molecules). Now these fibrils are also found in the buffy coat of inflammatory blood (§ 212); and there can, therefore, be no doubt that they are identical, and that the blood altered by the inflammatory process is the source of the deposit (§ 438). This leads us to anticipate, what is really the fact, that the plasticity of lymph depends very much on the good quality of the blood, as well as on the energy of the inflammation. Healthy blood, which abounds in red corpuscles as well as in fibrin, furnishes the most plastic kind of lymph (§ 183); and inflammation, attended with the most active determination of blood, (so long as the integrity of the vessels is preserved,) separates this lymph in the greatest abundance. This lymph already possesses living properties, for its materials arrange themselves into the basis of a texture: but to sustain the life of this texture, it is necessary that due supplies of blood should be furnished, and this is effected by the wonderful process of the formation of blood-vessels in it which become continuous with those of the adjoining parts.

451. The precise manner in which vessels are formed in lymph is still a matter of some obscurity. Mr. Kiernan has observed inflamed capillaries to become varicose, to project at points into pouches and diverticula, and to stretch into loops. If such pouches and loops were to give way, the blood would be injected into the lymph; and if something of the nature of channels had been previously formed by the arrangement of the fibrils, or by the elongation and communication of cells, it is quite conceivable that a current might be produced through several openings by the *vis à tergo*, and that a return of the blood might take place in consequence of a reversal of the weaker currents. Mr. Travers has noticed a process somewhat resembling this; he has seen solitary

red corpuscles make their way into a bed of lymph globules, and after for some time exhibiting an oscillating movement, give way before a current. The oscillatory movement most probably depends on the pulses of the heart, as the analogous motion described in obstructed vessels does (§ 418). Vogel speaks of new vessels, and even of the blood within them, as being directly produced out of the blastema, independently of previously existing vessels; but if this observation were correct, we might expect frequently to meet with the appearance of vessels in detached masses of lymph, and throughout the thickness of the large clots that accumulate on serous membranes. It has been ascertained by Schroeder, Liston, and others, that the new vascular channels are at first much larger than the vessels which supply them; they are afterwards contracted by the formation of a basement membrane lined with epithelium; and the whole texture becomes more consistent and less bulky, exhibiting a filamentous and cellular structure, with nucleated cells scattered through it. These new membranes form patches on, or adhesions between, the serous coverings of the lungs, the heart, and the intestines; and provided they are loose, flexible, and of moderate thickness, they may cause no disorder. It was for a long time considered, in consequence of the frequent formation of plastic deposits after inflammation, that this process was really Nature's plan for repairing injury to structure, but Dr. Macartney has shown that this is not the case. He has pointed out that generally the powers of repair are in inverse proportion to the tendency to inflammatory action, and that this action retards rather than aids repair. Inflammation is only really salutary when there is deficiency of fibrin, and therefore of organizable power, in the blood. It then causes the supply of the deficient principle. Inflammation renders the plastic supply of fibrin more abundant, and hence the filling up of a wound by granulations is a more rapid process than the more perfect formation of structure that takes place in the absence of inflammation, but the temporary deposit has then to be subsequently removed, and more highly organized tissue substituted for it.*

452. When the subject is unhealthy, when the inflammation is of a low character, or when the blood is poor in red corpuscles, or more especially when these conditions are combined, the solid products of inflammation are less capable of organization, and therefore

* See Macartney's Treatise on Inflammation, page 7.

may be called *cacoplastic*. Generally the appearance of the lymph when first effused gives evidence of its inferior plasticity: it is more opaque, less cohesive, and under the microscope, exhibits a predominance of the pale corpuscles, with fewer and less regular fibrils. The varieties of lymph designated *corpuscular* by Mr. Paget, and *croupous* by Prof. Rokitansky, are either of this kind or of a still lower degree of organization. As the process of organization varies in degree of completeness, so these products attain to different stages of perfection, and form membranes of a denser, less pliant texture and of less vascularity, than the serous membranes to which they are attached, and which they therefore shackle. Thus patches of a kind of fibro-cellular, or fibro-cartilaginous membrane, are often formed in the lungs, the heart, and the intestines; sometimes with the effect of materially impeding the functions of these several organs. Where the effusion of lymph is scanty and slow, its granular mode of deposit is more obvious than in more acute disease; for being less ductile, it is less readily spread or stretched by the motion of the parts (§ 449). This is well seen in chronic inflammations of the peritoneum and arachnoid membrane, in which the deposit is almost entirely in granules or flattened patches, commonly called tubercles. These are generally of a buff or skin colour, of firm consistence, and sometimes there are slight traces of blood-vessels in them;* but sometimes their colour is more yellow, they are more opaque, their texture is uniform and tough, and they are destitute of vascularity. They then constitute the formations described under the names cirrhosis and crude yellow tubercle, and are the lowest of organized products. Being, in organization and consistency, dissimilar to the membranes on which they are formed, they prove a source of irritation and constriction; and being liable to ulterior changes, (shrinking and contraction in the case of cirrhosis; further degeneration and softening in the case of yellow tubercle,) they may lead to extended mischief in contiguous parts.

453. In some cases, again, more or less of the solid product of

* Mr. J. Dalrymple has observed, that the vascularity of lymph may be seen earlier, in cachectic and scorbutic, than in healthy subjects. But syphilis and scurvy may moderate inflammation, without rendering the lymph aplastic: the great impediments to organization of lymph are, its bad quality and excessive quantity, and the persistence of inflammation. Mr. D. has shown, that even a large coagulum of blood may soon become vascular in a scorbutic subject; but it does not follow that either this or lymph in such subjects can be formed into real texture.

inflammation is *aplastic*, or totally incapable of organization, and is thrown off with the liquid, in numerous separate cells filled with granules and molecules, constituting pus; or it is deposited in detached opaque flakes or curds, consisting of aggregations of irregular granule-cells, oil-globules, and molecules, held together by a few fragments of fibrils; the whole pervaded by and contained in serum: such effusions are exemplified in the sero-purulent liquid and curdy matter of low pleurisy, pericarditis, and peritonitis. It is obvious that such lifeless products must act prejudicially on the containing structures; and as might be anticipated, they are little susceptible of absorption.

454. I have mentioned (§ 452) a low form of inflammation, and an unhealthy condition of the blood, as causing the cacoplastic character of the products of inflammation. It may be added, that the long continuance of any inflammation, and its occurrence in subjects in whose blood fibrin abounds, while the red corpuscles are scanty (§ 185, 195), will pretty surely render its products cacoplastic or aplastic. At the onset of inflammation its products may be plastic, and the process of vascular organization (§ 451) may commence; but if the inflammation continues, the effusion either is thrown beyond the reach of vascular communication, or it displaces that already effused, then the outer layer is in a degenerating condition. But besides this, the pressure of the effused liquid may impede the construction and injection of the new membrane, which therefore degenerates into one of the cacoplastic or aplastic matters above described. Again, in scrofulous or cachectic subjects, the blood, although scanty in red corpuscles, abounds in fibrin, and this is readily effused in inflammation; but it is of low vitality, and susceptible of little or no organization.* There is yet another circumstance tending to lower the plasticity of lymph, although, according to the observation of Mr. Dalrymple, it some-

* When a coagulum of fibrin is retained long in a vessel without becoming organized, it loses its structure, and softens into an opaque semi-fluid matter, which long was mistaken for pus; but Mr. Gulliver first showed that it consists of much smaller particles, mere irregular granules and fatty globules; and in fact that many cases that were formerly considered as inflammation of veins were simply examples of this softened fibrin. In this state it bears the closest general and microscopical resemblance to mature and softened tuberculous matter. It appears to me, that certain softened tuberculous appearances, met with in the lymph of serous membranes and parenchymata, are similar in their nature. We now know that fibrin and similar matters are prone to a spontaneous conversion into fatty matter, which, appearing in minute globules, disintegrates and breaks up the solid into an opaque granular pulp.

times accelerates its organization*—that is, the admixture of the colouring matter of the blood with it. Laennec supposed that contraction of the cavity of the chest had its origin in hæmorrhagic pleurisy only. This is not correct; but I have many times remarked after death, that lymph on the pleura and pericardium in cachectic subjects, is much stained with blood; and I have found that where patients with similar symptoms have recovered from the inflammation, they have been subsequently affected with structural disease. It is very probable that in such cases the colouring matter is itself diseased (§ 186).

455. The more complex structure and nature of *mucous membranes* considerably modify the form and appearance of the products of their inflammation. But according to Gerber, Henle, and Gruby, they may be seen by the microscope to consist of pus and mucous globules, granular cells, granules, and molecules, together with more or less amorphous and glutinous mucus and scales of epithelium. I must add, however, that in the early stage serum is present, as is manifest from the saline taste and coagulability by heat; and at an advanced stage, the mucus acquires a considerable increase of fatty matter.

Irritation of mucous membranes merely causes a flux (§ 379), that is, renders the natural mucous secretion more copious, watery, and saline than usual, and containing fewer cells. But if the irritation be continued, and inflammation follows, the secretion is at first diminished by the effusion of serum and pale corpuscles into the interstices of the mucous and submucous texture, and this causes more or less thickening or swelling. Soon, however, the effusion overflows to the surface in the form of a more or less viscid, saline-tasted liquid, containing globules and epithelium scales; and as the inflammation gets more intense, the cells or globules predominate, and the mucus becomes scanty, but is still very viscid. On the first decline of the inflammation, the mucous and saline matters diminish, whilst the fatty matters increase, and the corpuscles compose the chief mass of the secretion, and give it the yellowish or greenish opacity seen in "concocted" sputa; and this opaque matter is afterwards gradually replaced by the natural mucous secretion. In many cases, especially in young subjects and others in whom the inflammation penetrates to the submucous cellular texture, fibrinous matter is thrown out, forming films or

* Medico-Chirurg. Trans., 1840, p. 212.

shreds of lymph, or giving a fibrous or curdy appearance to the mucus, as in croupy inflammation: but this fibrin very rarely becomes organized on mucous membranes, because their secreting apparatus and secretions lie between the lymph effused and the vascular structure. Hence the exudation corpuscles of inflammatory mucus are degenerating or aplastic, and constitute the opacity of the viscid muco-purulent, purulent, and shreddy fibrinous matters exuded by inflamed mucous membranes. If inflammation persists in a mucous membrane, the cells continue to abound in the effusion, commonly rendering it opaque and purulent; and the natural mucous secretion being impaired, the product is more diffluent. But inflammation rarely continues long over a great extent of surface; it is confined to patches, which yield their opaque effusion whilst other parts may be secreting natural mucus. Hence the mixed appearance of the secretions in chronic inflammations of mucous membranes (bronchitis, mucous enteritis, and cystitis).

Sometimes interstitial effusion, which takes place at the commencement of inflammation of a mucous membrane, is not entirely removed by the subsequent discharge. In such cases there may remain a permanent thickening of the mucous and submucous texture; this is the cause of the indurations and strictures which inflammation sometimes leaves in the intestines and urethra; and to a less degree in the air-passages. This, however, it must be observed, is the result of inflammation of the submucous cellular texture rather than of the mucous membrane itself.

456. Inflammation of the *skin* presents great variety as to the amount and kind of its products. The full consideration of these would lead us into the pathology of skin diseases, a subject replete with interest and practical importance, although sadly neglected amidst the artificial distinctions of writers on cutaneous disorders; but the subject is too wide to be discussed here.

Some of the effusions in and from the skin have been glanced at under the head of the symptoms of inflammation (§ 432). It may now be added, that these effusions may consist of clear serum, with few exudation corpuscles and molecules, as in the liquid of blisters and blebs, and of eczema, which dries into thin scabs; or of milky serum more abounding in the corpuscles, which dry into thicker scabs, as in herpes, rupia simplex, &c.; or of liquor sanguinis and purulent serum, with more numerous corpuscles, which form very thick yellow or brown scabs, as in rupia prominens, im-

petigo, and ecthyma: or the effusions may be chiefly solid, and thrown into the substance of the true skin, as in tubercular inflammations and incipient pustules. In all cases of inflammation of the skin, there is an increased production of epidermis, which is sometimes thrown off in scales with the scabs; or in a peeling of the cuticle; or it thickens, and forms a hard covering, liable to clefts and sore ulcerations, as in psoriasis, inveterate eczema, &c.

457. Inflammatory effusion into the *cellular texture* consists of serum, with more or less of the exudation corpuscles and fibrin. In diffuse erysipelas or cellulitis, the fibrin is deficient, and the corpuscles either are in moderate numbers, or else they are degenerative (purulent). In phlegmonous inflammation there is more fibrin, which circumscribes the effusion, and causes a harder swelling; and the pressure of this, with a continuance of inflammation, sometimes leads to suppuration or sloughing.

458. Effusions from inflammation of *parenchymatous organs* resemble those from inflammation of cellular texture; but the parenchymata in general being very vascular, as well as yielding, the solid effusion may be very copious, and yet not cause the pressure or tension that leads to suppuration and gangrene. The lymph effused exhibits, in regard to plasticity, the same varieties which we have described in the products of serous membranes, (450, *et seq.*) But inasmuch as lymph effused in the parenchyma of an organ would greatly interfere with its function, we rarely find it organized, except in limited portions, which thus remain solid and dense. More usually the matter deposited is gradually removed by absorption or secretion after the inflammation declines; or if the inflammation continues, the exudation globules and lymph are converted into, or replaced by, various kinds of pus or tuberculous matter—consisting of degenerated corpuscles, granules, and fatty globules.

459. Effusion so closely attends the process of inflammation, that the *symptoms* of effusion have been comprehended in those of inflammation. Swelling, pressure, obstruction, irritation, consolidation, displacement, and various functional, as well as structural disorders, may arise from the presence of effused matter. Hence the occurrence of effusion may aggravate some of the symptoms of inflammation, whilst others may be more or less relieved by it. Where a copious effusion takes place, the pain, heat, redness, and fever, are commonly reduced: for the vascular and

nervous excitement and determination of blood are thereby lessened; but the local or visceral disorder may be increased. The pulse may be as frequent, but it is less hard and full; the fever less constant, but it may continue in a lower degree, or assume a remittent or hectic form. The relief by effusion is greatest in slight inflammations, or where the effused matter can be thrown off from the body, as in the case of mucous membranes; but there may be much irritation and exhaustion of strength caused by the process of throwing it off, (as in cough and expectoration, diarrhœa, purulent micturition, &c.;) and these will be more harassing where, as is sometimes the case, the effusion does not remove the inflammation.

Suppuration and Ulceration.

460. The formation of pus among the products of inflammation has been several times noticed (§ 424, 453, 455, 457, 458). Pus is an opaque greenish or yellowish white liquid, of creamy consistence, little odour, and of specific gravity varying from 1030 to 1033. It is chemically composed of water, deutoxide of protein forming the cell walls, tritoxide of protein and albumen in solution, fat, extractive matter, and the same salts as those in the blood. Recently formed pus contains more albumen and fat than is found in the liquor sanguinis; but according to Gerber, mature pus contains more fat and less albumen than that recently formed.

Microscopically, pus is seen to consist of a limpid serum, and very numerous globules of pretty regular size and form. These globules have much resemblance to granular cells or exudation corpuscles* (§ 424), but they are more opaque and are more distinctly and constantly provided with a cell wall and nucleus, in addition to granules and molecules. Vogel describes their form to be in general spherical; but sometimes irregularly rounded or oval: their cell wall is commonly opaque, and somewhat uneven from being studded with minute granules; so that their contents may not be apparent without the addition of acetic acid, which renders the walls transparent, and brings into view their nuclei, which then take the form of from one to five somewhat elliptic disc-shaped bodies clustered together and attached to the interior

* Mr. Paget has also pointed out the close analogy between the granular corpuscle and pus-cell: in fact, he considers the latter to result from the degeneration and partial liquefaction of the former (Lectures, vol. i. p. 231), which nearly accords with the views previously expressed in this work.

of the cell. The existence of the cell in most pus globules is also made clear by the action of distilled water, which causes the cell to dilate (by osmosis) to double its former size; the larger granules or nuclei swell also, and this shows their vesicular nature. According to Mr. Gulliver, they measure on an average $\frac{1}{2666}$th of an inch in diameter.* They commonly differ from the exudation corpuscles also in being more distinctly vesicular, and containing a fluid, as well as granules: they more readily swell, burst, and shed their contents under the influence of water or potass (Addison). In some instances, Vogel admits pus globules to be devoid of a distinct cell wall; this I have stated to be the case with some of the white or granular corpuscles, and the only distinction of this kind of pus globules is found in its exhibiting a peculiar trefoil or cordiform nucleus under the action of acetic acid.

461. Another distinguishing character of the pus globules is their want of cohesion; hence in proportion as they predominate, they impair the consistence of fibrin or mucus with which they may be mixed. In this respect they contrast remarkably with the white corpuscles, which both within and without the blood-vessels manifest a remarkably adhesive and cohesive property. This and the other differences may be all explained on the supposition that the more gelatinous or semi-solid parts become completely fluid in the pus globule, whilst the cyst becomes more solid, and tougher than before: such a change would account for the vesicular form and incohesive properties of the globules of pus; and the extension of a similar change to the larger of the contained granules, would equally convert them into minute cells, which have the appearance of nuclei, with the usual osmotic properties. This liquefaction accompanying the formation of pus, is not confined to the contents of the pus globule, nor even to the plasma, lymph, and other products of inflammation; it extends to the containing vessels and textures, which are softened, disintegrated, and removed, in proportion as the suppurative process proceeds. In complex textures, therefore, whence the pus cannot escape, this process consists not merely in the formation of pus, but also in its substitution for

* Pus is not commonly produced in birds or in cold-blooded animals: the reason of this is not understood, as the exudation corpuscles do not materially differ from those of mammalia, although the red corpuscles are oval. In the camelidæ also, in which the red corpuscles are oval, the pale corpuscles and pus globules are round.—Gulliver; Med.-Chir. Trans., 1839, and Phil. Mag., 1842.

more or less of the inflamed texture: for this reason suppuration, more than effusion, may be called a termination of inflammation, for the inflamed vessels are in great part destroyed.

The chemical change which accompanies and probably causes this disintegration and liquefaction in the formation of pus, seems, according to the researches of Mulder, to be an increased oxidation of the protein, whereby it passes from the state of a solid deutoxide into that of a tritoxide, which is readily soluble in water or serum. But this further oxidation and solution implies also a reduction of vitality in the exuded corpuscles, which thus lose their organizing power, and degenerate into a loose aplastic material. Probably in some instances the corpuscles are originally defective in organizing power, and are therefore prone to degenerate; whilst in others they become so from defective nutrition or from some interruption to their plastic power. We shall find that the circumstances which promote suppuration, the nature of the process, and the symptoms which accompany it, exactly correspond with this view of the subject.

462. The circumstances which determine suppuration as a result of inflammation, are chiefly three:—1. A certain intensity and duration of the inflammation; 2. The access of air to the part; 3. A peculiar condition of the blood.

1. Intensity and continuance of inflammation comprise the persistence of the two chief elements in the process, determination of blood and obstruction (§ 419); and as we have seen, that the physico-chemical effect of these is first to direct the force and to exaggerate the influence of the red corpuscles (which convey oxygen), on the liquor sanguinis, so that more of its protein passes into the state of solid deutoxide—a material fitted for organization and reparation:—so we may infer that the excessive degree or continuance of the same action may overdo the change, give chemical properties an ascendency over the vital powers; and by turning the most recently formed solid into a fluid tritoxide, it may effect a work of separation and destruction, involving the blood in the obstructed vessels, and extending to the albuminous matter of the containing texture. Such a result is most likely to ensue in complex and highly vascular structures, in which the effused matter is retained in intimate contact with the blood-vessels: hence intensity and continuance of inflammation in the true skin, cellular textures, glands, and most parenchymatous organs, pretty surely

lead to suppuration. In serous and fibrous membranes, on the other hand, suppuration is a rarer result, because the vessels are few, and the effused corpuscles placed less within their influence. In partial external inflammations, suppuration may often be prevented by pressure, which acts by diminishing the determination of blood, and therefore by reducing the oxygenating influence.

2. The access of air to a wound or to a serous membrane is well known to promote the formation of pus; and it may do so mainly by directly supplying oxygen, and converting the fibrine, and part of the exudation corpuscles, into the soluble tritoxide of protein; but air may also operate as an irritant to a serous membrane or abraded surface, increasing the intensity of the inflammation, and promoting the degeneration of its products. A limited access of air to a large quantity of pus leads to a decomposition of the matter and the production of sulphuretted hydrogen, which acts as a deleterious poison on living structures.

3. That a peculiar condition of the blood promotes the occurrence of suppuration after inflammation is obvious from the readiness with which all wounds, scratches, and pimples then fester, and with which inflammations of no peculiar intensity lead to the early formation of pus in different structures. This state of the system constitutes what has been called the *suppurative diathesis*, and is presented in cachectic or ill-conditioned subjects, the quality of whose blood has been injured by mal-nutrition, imperfect excretion (§ 171, 187), or by the direct operation of some morbid poison (§ 258, 296) such as that of erysipelas, confluent small pox, glanders, &c. Mr. Paget found on examining the fluid exuded in blisters raised by cantharides plasters applied to the skin, a variety of products illustrating the difference in the products of inflammation resulting from constitutional causes. "Thus, in cases of purely local disease, in patients otherwise sound, the lymph thus obtained formed an almost unmixed coagulum, in which, when the fluid was pressed out, the fibrinous, firm, elastic, and apparently filamentous masses at the opposite end of the scale, such as those of advanced phthisis, a minimum of fibrine was concealed by the crowds of corpuscles imbedded in it. Between these were numerous intermediate conditions which it is not necessary now to particularize. It may suffice to say, that after some practice, one might form a fair opinion of the degree in which a patient was cachectic, and of the degree in which an inflammation

in him would tend to the adhesive or the suppurative character, by these exudations. The highest health is marked by an exudation containing the most perfect and unmixed fibrine; the lowest, by the formation of the most abundant corpuscles, and their nearest approach, even in their earliest state, to the character of pus cells. The degrees of deviation from general health are marked either by increasing abundance of the corpuscles, their gradual predominance over the fibrine, and their gradual approach to the character of pus cells; or else, by the gradual deterioration of fibrine in which, from being clear, elastic, tough, and uniform, and of filamentous appearance, or filamentous structure, it becomes less and less filamentous, softer, more paste-like, turbid, nebulous, dotted, and mingled with minute oil molecules."—(Lectures, vol. i., p. 338.)

But the most efficient cause of the suppurative diathesis is the abundant presence of pus itself in the blood (pyæmia), as occurs in cases of phlebitis, diffused suppuration, &c.; and indeed it is most probable that this cause really exists in the examples above mentioned also; for Mr. Gulliver and others have detected pus globules in the blood in many such cases (although this has been denied by Lebert and Rokitansky); and there is good ground to suppose that in all cases of suppuration some of the granular corpuscles are converted into pus globules within as well as without the vessels; but for reasons that will afterwards be explained, this takes place only to a very limited extent under ordinary circumstances. The conversion of the white or exudation corpuscle into the pus globule always implies a lowering of vitality; and therefore a peculiar proneness to the change (independently of intensity of inflammation and exposure to air) indicates a feeble state of the vital powers, rendering them unequal to resist chemical affinities. In extreme cases this tendency shows itself by the occurrence of gangrene, which often supervenes in the worst form of pyæmia, as in malignant erysipelas and phlegmon. It is therefore quite intelligible that pus, when present either in a part, or in the blood at large, may act in the mode of a chemical ferment, promoting the formation of more like to itself, and tending to degrade the plasma of the blood from that organisable condition in which it can repair breaches or sustain the nourishment of the body. This inference seems warranted by numerous chemical facts, although microscopical observers do not agree as to the fact of the constant presence

of pus-cells in the blood. In all probability the infection in pyæmia may be from the *liquor puris* as well as from the pus-cell itself; this appears to be the opinion of Rokitansky.

These considerations will throw much light on the further process and symptoms of suppuration.

463. The process of suppuration strongly illustrates the opposite character of the elements of inflammation before alluded to (§ 421). The obstruction to the passage of the blood through the capillary vessels of an inflamed part, and the increase of this obstruction by the pressure of material effused by those vessels that are the seat of determination, reduce the vitality of the tissues to so low a degree, that they are unable to withstand the chemical power of the effused fluids,* acting as solvents, and exalted as it is by high temperature. The textures are therefore gradually disintegrated, dissolved,† and absorbed away, whilst the exudation corpuscles degenerating and softening into pus-cells, occupy their place, and continue to be effused and developed by the vessels which are still the seat of determination of blood.‡ This assumes that absorption is still active in an inflamed part; and the assumption is warranted by the fact, that the absorbed vessels, veins and lacteals, remain perfectly free: the very occurrence of increased pulsation and flow in communicating and contiguous vessels (§ 413), will promote the exosmosis of fluid matter by the absorbent vessels. That the pus globules should remain unabsorbed will not appear extraordinary, when their size is taken into account (§ 460), and also the fact that their cysts are not dissolved by their proper fluid, having acquired a remarkable degree of toughness. Their

* That the liquid of pus can chemically dissolve dead animal matter was proved by J. Hunter, who found that pieces of raw meat were dissolved in abscesses, or even in pus kept warm out of the body. The experiments of Sir C. Wintringham show that other animal fluids have a like property. Dr. Prout notices similar facts. This solvent property we have now reason to ascribe chiefly to the formation of the soluble tritoxide of protein. A similar change takes place during the cooking of meat; so that the old expression *concocted matter* is not altogether metaphorical. Nor is the familiar term of *ripening* of an abscess derived from an analogy wholly imaginative. The ripening of fruit and other vegetables depends on a spontaneous liquefaction of parts previously solid having a resemblance both chemical and histological to the process of suppuration.

† The idea that the removal of textures in suppuration is owing to their death, originated with Dr. Billing. (See his "Principles of Medicine.")

‡ That absorption is increased in an inflamed part is further proved by a direct observation of Kaltenbrunner, who watched the gradual disappearance of the pigment spots in the frog's web. This, however, was not the result of suppuration, as that process does not occur in cold-blooded animals.

large size is wholly opposed to the notion that they are effused from the blood-vessels as pus globules; but their arising from the exudation granules and cells easily accounts for their appearance in the midst of lymph, and other products of inflammation, which they supersede as they enlarge and multiply. Thus the combination of apparently opposite results, which has been considered so inexplicable,—excited and lowered action, increased secretion, and increased absorption—admits of an explanation that is in exact accordance with all the observed phenomena.

464. The amount and extent of the process of suppuration varies in different cases. In cellular and parenchymatous textures it sometimes occurs as *purulent infiltration*, not circumscribed by lymph, but leaving the texture much softened, and partially removed. This diffused kind of suppuration is to be referred either to the porous nature of the organ (as with the lungs) not admitting an effusion of lymph sufficient to limit the suppuration, or to a purulent diathesis or disposition in the blood (§ 462). In most cases, the process of suppuration is limited by solid effusion, which may be either the remains of the earlier product of the inflammation, or it may be thrown out expressly for the purpose of defending the adjoining structure from the operation of the pus, obviously so noxious a matter. A collection of pus thus circumscribed is called an *abscess;* and when mature, it represents the perfection of suppuration. The blood-vessels of the inflamed part are destroyed like other textures: but their supplying trunks are obstructed by lymph; whilst the adjoining capillaries remain pervious, become dilated and varicose on the walls of the abscess, (which are composed of layers of organized lymph,) and continue to secrete pus; hence this lining is called the *pyogenic* membrane. As the pus increases in quantity, the abscess becomes enlarged, generally towards some cutaneous or mucous surface, where it is said to *point:* the skin or covering membrane ulcerates, and the pus is discharged. The direction, which the abscess takes, seems to be that in which there is least resistance: the parts there are more stretched than in other places; and from being stretched, their vessels get more obstructed, so that they cannot maintain the vitality, nor throw out the same amount of protecting lymph, which limits the extension of the abscess in other directions. Fibrous and other hard textures resist the progress of abscesses and the escape of pus. Serous

membranes, in consequence of their proneness to become plastic at their surfaces, first adhere together, and then often give passage to the contents of an abscess through the adherent layers, without allowing any pus to escape into the interior of the sac. In this manner abscesses of the liver and kidney make their way across the peritoneum into the intestines, through the walls of the abdomen, and even through the diaphragm, pleura, and lungs. Where pus does make its way from an abscess into a serous sac, it causes severe irritation, and commonly fatal inflammation.

465. After an abscess has opened, it may continue to discharge pus, pure, or diluted with serum or sanies; but in healthy subjects, a process of healing takes place by an increased effusion of lymph, throughout the interior of the abscess, and the growth of new vessels in this lymph in the form of *granulations*. Pus is still formed by the degeneration of the superficial layer of exudation corpuscles; and a free vent must be given to this pus until the growth of the granulations and the contraction of the walls shall have obliterated the cavity of the abscess, and left no more room for the pus to accumulate.

466. *Ulcers* sometimes arise from abscesses: an abscess that has discharged its contents is, in fact, an ulcer. But more commonly, ulcers originate from limited inflammations of the skin or mucous membranes, in which the natural cohesion of the tissue is so much impaired by the solvent action of the effusions on it, that it is broken up at one or more spots, and is either carried away in the pus discharged, or is absorbed. There is then left a solution of continuity or excavation, the bottom and edges of which continue to discharge pus, or a serous fluid mixed with exudation corpuscles, and sometimes blood corpuscles. Ulcers may tend to spread by the same process as that which forms them at first; or to heal in consequence of the effusion of fibrin on their walls and the extension of vessels into this in the form of granulations, which are then the materials of the new texture. Ulcers however present a great diversity of character as regards the nature of their secretion, and the condition of their walls, as well as regards the symptoms which they produce: these circumstances are considered in surgical works.

The cause of ulceration is commonly local; inflammation suspends the normal nutrition of a structure, and leads to its solution. (§ 460, 3). Ulceration is often preceded by induration from solid

deposit; and the ulceration commences in the centre of the induration, because the nutrient influence of the vessels is most reduced by the pressure at that spot. But a very poor condition of the blood (hypinosis, § 196) is often concerned in determining this result, and seems to be sometimes sufficient to cause ulceration without any distinct previous induration, or even inflammation; the parts that suffer being either those which have become congested by posture (as occurs in cachectic ulcerations of the legs), or those most remote from the nourishing influence of the blood (such as the non-vascular textures, the cornea, cellular parts of cartilages, &c.) Ulcers of this description arise in cases of extreme anæmia (§ 268), where the fibrin and albumen of the blood are very defective (§ 197), and are then to be counteracted by measures the very opposite to antiphlogistic. A similar result was found, by Magendie, to ensue in animals fed on sugar, starch, and other non-azotised articles of food. In these instances the ulceration and destruction of textures may be referred to the solvent powers of the oxygen of the blood being exerted on materials whose vital powers of resistance (§ 16) have been much reduced, and when there is no supply for their renovation in the plasma of the blood.

467. *Softening* of textures may arise from the same process which, when acting in a greater degree, and in more circumscribed space, causes ulceration. It has already been spoken of as one of the effects of inflammation (§ 427); and it may now be added, that the condition of the blood which disposes to ulceration sometimes leads to the more diffused operation of the same change in the softening of textures. Thus softening of the brain, liver, muscle, and mucous membrane, sometimes results from anæmia, or imperfect supply of blood to these parts, or from spanæmia or impoverished condition of the blood supplied (§ 197); and inflammation, which impairs or deranges the supply, may immediately determine the occurrence of the softening process.

Local Symptoms of Suppuration.

468. It may be gathered from the previous statements, that suppuration is a work of destruction, and is therefore in some measure, to be contrasted with effusion of lymph, which is intended to be a process of construction or reparation. Pus is totally aplastic itself; it is formed at the expense of the plastic product of the vessels, and the liquid of pus seems to act as a solvent or

septic on textures whose vitality has been reduced. Although, therefore, suppuration is often useful by terminating inflammation, and by removing superfluous products, and parts that have been injured by it or its causes, yet suppuration must on the whole be viewed as a depressing and exhausting process, and its product as having a noxious character: the symptoms which accompany it will be found to correspond with this view.

469. The occurrence of suppuration is marked by a diminution of the heat, pain, and of the other signs of irritation and increased action in the part. The pain often becomes throbbing, as if the external pressure on some of the larger vessels had momentarily yielded, and they had become expanded at each pulsation. The swelling gets softer; and if within the reach of touch, may be felt to be first more yielding under the finger, and afterwards to present the fluctuation of fluid matter. The redness present in inflammation is also diminished, being wholly superseded by the pale yellow of purulent effusion in the central parts of the suppurating mass, being mottled by it in others, and retaining its deep character only in those circumferential parts to which the suppuration has not reached. In external inflammations, the redness of the skin becomes deeper before suppuration; but when this process reaches the skin, a pale spot is seen, which by its fluctuating feel indicates the approach of the abscess to the surface.

The great reason why the symptoms of inflammation are alleviated, on the occurrence of suppuration, is that the tension and hard swelling, which chiefly cause the pain and irritation (§ 433), are diminished; for where suppuration takes place amidst unyielding parts, as under a fascia, or within a bone, the tension is increased rather than lessened, and then the symptoms of pain and irritation are often more severe than ever. The powerful influence of hydraulic pressure in causing the injection of a liquid into a compact texture, and the swelling of the pus globules by osmosis or cell secretion after their first formation, will assist in explaining the effusion of pus under a dense periosteum or theca, and the extreme pain and irritation which this produces. The free secretion of pus from mucous membranes relieves inflammation, and removes the submucous deposit (§ 455).

General Symptoms of Suppuration.

470. The influence of suppuration on the system is manifest in

the lowering of the inflammatory fever; the pulse loses its strength, but retains its frequency; the heat subsides, or alternates with chills and sweats; the general redness is succeeded by paleness, or a hectic flush; the urine deposits a pale or pinkish sediment;* and the general excitement gives place to weakness and exhaustion. The amount of this change greatly depends on the extent of the suppuration, and the importance of the organ affected; but another circumstance that modifies the effect of suppuration, and that proves the noxious influence of pus on the system, is the difference as to whether the suppuration is diffused without a circumscribing barrier of lymph, and whether it is thus limited, or whether its product is thrown off at once from the body.

In some cases of inflammation of the cellular texture, skin, and serous membranes, pus is formed with little or no previous exudation of lymph, and produces in the system the most formidable effects. The pulse becomes very frequent and weak; the tongue brown and dry, or coated with an offensive fur, and tremulous; sweats break out profusely; the urine is scanty, high-coloured, and fœtid, or sometimes even suppressed; a putrid diarrhœa occasionally occurs; hiccup and subsultus come on; the mind is much depressed, or excited by occasional delirium; the patient's manner and motions are agitated and restless; the breathing becomes hurried and sighing; and death may ensue in from one to four days from the commencement of these symptoms. Similar results ensue in suppurative inflammation of veins; and in injuries of the head ending in suppuration, that involves communication with some of the venous sinuses; they have also been known to follow where an external abscess has suddenly subsided without opening, and in cases in which the discharge from a large suppurating wound has suddenly ceased. On opening the body after death, in a few such cases, nothing peculiar has been found, except a general fluidity of the blood, and the gravitative congestions and stains which that fluidity induces (§ 196). In most instances, however, there are found in some of the viscera, particularly the lungs and liver, *purulent deposits*, as they are called; collections of pus, generally confined to lobules or portions of lobes of these viscera,

* The occurrence of urinary sediments after suppuration has been noticed by Schonlein as a constant phenomenon; but such sediments are also observed after inflammation without suppuration, and must be regarded as the debris of plastic matter, and of textures that have been *wasted* during the inflammatory process.

with more or less inflammatory injection and a scanty deposition of lymph around the collections. In these cases, there can be little doubt that pus or its serum has been in some way conveyed in the circulation; and then been arrested in the lungs and liver, leading to the formation of more like itself (§ 462), sometimes by the production of local suppurative phlebitis, as supposed by Cruveilhier, Dance, and others; and sometimes by a contamination of the blood itself; and thus the pus in the blood is the proximate cause of the entire train of formidable symptoms and results. In several such cases purulent matter has been detected in the blood in considerable quantities, not only by the aid of the microscope, but in consequence of the pus globules forming a visible layer on the surface of the red corpuscles. The experiments of M. D'Arcet,* make it seem probable that the poisonous influence of purulent matter arises from the chemical changes that are induced by air in its serosity (§ 460); but that obstruction to the circulation in the lungs and liver, and consequent circumscribed inflammations of these organs, result from aggregation of masses of the debris of the pus globules contained in the blood; it has, however, been found by M. Lebert, and Mr. H. Lee, that the serum of pus injected into the veins of the more delicate animals, induced the fatal results of purulent infection almost as soon as when pus was injected entire.

In instances of the abundant presence of pus in the blood, it is not to be supposed that it is absorbed through the entire walls of blood-vessels; the large size of the pus globule, as before noticed (§ 463) forbids such supposition; but unusual channels of entry into the vessels have been in several cases discovered, as in the instance above alluded to of an abscess in the skull opening into one of the sinuses; to which it may be added that in suppuration in bones generally, the pus may find an easy entrance through the open venous canals; and in wounds of the neck it may be drawn in through the large divided veins under the suction influence of inspiration. Suppurative phlebitis has been already mentioned as an obvious cause of pyæmia. But we must again advert to the fact, first established by Mr. Gulliver, that pus globules appear in the blood in other cases of severe inflammation and suppuration where no opening into the veins is known to exist. In these

* "Recherches sur les Abscès Multiples," &c.; and Brit. and For. Med. Rev. Jan. 1843.

instances, as before stated (§ 463), the pus globules are probably formed within the vessels of the inflamed part; and these increase and produce symptoms of pyæmia only in cases in which the vitality of the blood is impaired, and in which there is a proneness to the formation of pus from trivial causes (§ 462). To this group of cases I would refer several instances of pyæmia with the bad symptoms before mentioned, which I have seen after scarlatina, and in a few cases of acute albuminuria and typhoid rheumatic fever. Probably, too, malignant erysipelas and metroperitonitis belong to this class.

471. The preceding observations prepare us for the fact that extensive local suppurations cause various symptoms of depression or low irritation, besides the effects specified above. Of this kind are the rigors often experienced at the commencement or increase of suppuration. Dr. Billing plausibly ascribes this to the system sympathizing at the death of the part which is under destruction by the suppurating process; but the rigor not always occurring suggests rather that the presence of a certain amount of pus in the blood may be its cause; this may induce the shivering merely as a depressing agent, or probably by directly interrupting the calorific process by the withdrawal of a portion of the oxygen which is essential to its sustenance (§ 461). This latter notion is countenanced by the remarkable and sudden fall of temperature which often accompanies the extensive formation of pus.

Again, when suppuration continues long, even if it be discharged outwardly, as in extensive wounds, or ulcerations of the skin or mucous membranes, there is great wasting of strength and flesh, with a partial febrile irritation of a peculiar kind, called *hectic fever*. This is remittent in its symptoms, the exacerbations recurring once or twice daily, beginning with chills and depression, and being followed by a frequent pulse, partial heats, especially of the cheeks, hands, and feet, and ending in a profuse perspiration. As this proceeds, the body more or less rapidly wastes, and the colliquative sweats and diarrhœa, vomiting, and aphthæ of the mouth, are so many proofs of the rapid decomposition and removal of the various structures, which tend to hasten the fatal result. The febrile part of hectic is most observed in the young and irritable; but the depressing and exhausting effect of extensive suppuration is illustrated in all cases, by progressive emaciation and cachectic pallidity of a peculiar sallow or stony hue.

472. The matter of abscesses is *laudable* or healthy in proportion as it is thick and opaque, uniformly liquid, and free from smell; for although, even in this state, it is fit only to be expelled from the body, and is prone to decomposition, yet if excluded from the air it will remain unaltered for a long time. The formation of such pus is pretty sure to be attended with a protection of lymph, and it is far less noxious than ill-conditioned sanious matter, the fœtor of which indicates that decomposition has already begun.

GANGRENE.

473. *Gangrene*, like the more complete forms of suppuration, may be well called a termination of inflammation, for the inflammation ends in the death of the part. In suppuration, the dying textures are softened and displaced by pus as fast as they die; in gangrene, the textures die more extensively than pus is formed, and they run into decomposition without being removed. In some cases, especially in limited gangrene, the dead portion is dissolved away at its circumference by the inflammatory exudation from the living parts, the activity of which is evinced by red vascularity at the line of disjunction; and the dead part is thus separated or *sloughed* from them; but if it be extensive, and the power of the living parts low, the separating process will not be accomplished before decomposition ensues, and this produces the appearances known as *gangrene* and *sphacelus*.

474. The circumstances which cause inflammation to terminate in gangrene are,—the complete suspension of the circulation of the part (§ 273), great injury to the composition of the blood, or the direct destruction of its vital properties. The circulation of a part may be destroyed by long-continued pressure, by severe contusion, laceration, or other mechanical injury, by extreme heat or cold, by strong chemical agents, by the excessive pressure of the solid matter effused in the early stage of inflammation, (as in carbuncle,) and even by an extreme amount of congestion.* The occurrence of gangrene is favoured by extreme weakness of the heart, the great moving power of the circulation; and is then most likely to happen in parts that are most remote from the heart, as is illustrated in various structural diseases of the organ, in low

* Two cases of gangrene of the lung which have occurred in my practice seemed referable to this cause.

fevers, and states of extreme exhaustion. It is also favoured by ossification, or partial obstructions of the supplying arteries, which, although adequate to maintain the ordinary nutrition of the part, cannot dilate to supply the increased demand should any injury or irritation take place. The agents, which cause gangrene by directly destroying the vital properties of the solids and fluids of the body, are various strong poisons, such as arsenic, sulphuretted hydrogen, the poison of the rattlesnake and other venomous animals, the poison of the plague, malignant scarlatina, small-pox, and erysipelas, glanders, &c. Various debilitating or noxious influences operating on the body may give a gangrenous tendency to inflammations from wounds, and injuries of any kind arising from accidental causes: thus, in ill-ventilated rooms, in crowded hospitals, where the atmosphere is impure from the number, disease, or filth of the inmates, malignant erysipelas, and hospital gangrene are apt to occur.

475. When an external part becomes gangrenous it loses all feeling and other vital properties; its colour becomes livid, leaden, greenish, or almost black, the cuticle rises upon it in blisters, and begins to exhale an offensive odour. The rapidity of this change depends much on the moisture and warmth derived from the adjoining living parts; in *dry gangrene*, the dead portion becomes horny and black instead of putrefying. For the converse reason, in internal parts the progress of decomposition is more rapid. The putrid matter affects the living body as a local irritant, and as a general sedative poison or depressing agent; and the symptoms vary much as one or the other of these two operations predominates.

In persons of robust constitution, active vascular system (§ 112, 120), and good blood (§ 195), a dead part arouses active inflammation and effusion of lymph in the surrounding living parts, and this may protect the system more or less completely from infection by the dead matter. In such cases, although gangrene be present, the predominant symptoms may be those of inflammation and inflammatory fever. But living parts, with all their activity, cannot long withstand the pernicious influence of dead and decomposing matter: so that if this matter be not soon thrown off in the form of a slough (§ 473), or liquefied in the inflammatory exudations poured out, the system becomes infected, and suffers from its poisoning and prostrating operation. This will happen

more surely and early, where the dead part is in the interior of the body, of great extent, surrounded by vascular texture, and where its decomposition is promoted by the warmth and moisture. In subjects of weak constitution, feeble vascular system, and blood defective in plastic matter (§ 196), the irritation of dead matter may fail to excite a protective (adhesive or plastic) inflammation, and the putrid or typhoid symptoms then show themselves earlier, and prove more speedily fatal. These symptoms are,—increasing feebleness and frequency of the pulse, reduction of the fever, collapse and extreme pallidity of the countenance, cold sweats, brown, dry, or clammy foul tongue, low delirium, or restlessness and agitation of manner, hiccup, fœtid diarrhœa, urine very offensive or suppressed, coma or syncope, and death. In external parts, or in parts which communicate with the surface, the putrid odour of the gangrenous structure becomes a distinguishing physical sign; in gangrene of the lungs it is communicated to the expectoration and breath; in other cases, the whole body exhales a fœtid odour.

The supervention of gangrene sometimes terminates the pain and other severe symptoms of the preceding inflammation, and thus induces a false calm; but they are often replaced by distressing symptoms of nervous irritation, which subside only with the collapse of death.*

476. In concluding this account of the results or terminations of inflammation, I must repeat what was said at the beginning, (§ 445), that they rarely occur quite separately one from another, and in many instances they are all exhibited in different portions of an inflamed organ or texture. Thus resolution is always attended with some amount of effusion: lymph often has the colour, opacity, and much of the microscopic character of pus; suppuration is almost always preceded, and generally accompanied, by the effusion of some lymph; abscesses are often attended with gangrene and sloughing of parts: these combinations are further illustrated by the terms, *purulent lymph, flaky pus, sloughing ulcer,*

* For much instructive information on the subject of mortification, as well as on other matters connected with this chapter, see Mr. Paget's admirable Lectures on Surgical Pathology. Although he differs from me in a few points, I am gratified in being able to refer to the works of this excellent observer for a confirmation of many of the statements and opinions which I have long since put forth.

gangrenous abscess, &c., which pathologists are obliged to employ in describing the things they see.

VARIETIES OF INFLAMMATION.

The character of inflammation varies with the predominance or defect of one or other of its constituent elements or results, or in consequence of its combination with some of the other elements of disease that have been already considered: or again it may be greatly modified by the nature of the exciting cause, as is exemplified in what are called *specific* inflammations. The following peculiarities of inflammation require to be briefly noticed:—*sthenic and asthenic; acute, subacute, and chronic; congestive; phlegmonous; erysipelatous; pellicular or diphtheritic; hæmorrhagic;* and *scrofulous.* Of the specific inflammations, the *gouty* and *rheumatic,* the *syphilitic* and the *gonorrhœal,* will be merely alluded to.

477. The varieties of inflammation termed *sthenic* and *asthenic* correspond with the analogous varieties of plethora (§ 279), hæmorrhage (§ 360), and flux (§ 393), and are referable to a difference in the strength and irritability of the heart and arteries, and in the quality and quantity of the blood which they propel (§ 110, 120, &c.) Thus *sthenic* inflammation is marked by a strong hard pulse, high fever (§ 442), very fibrinous blood (§ 208, 438), a full and active development of the chief symptoms of inflammation (§ 429), and a tendency to the effusion of the more plastic products (§ 450). Patients affected with sthenic inflammation require and bear more antiphlogistic treatment than others; and if used in time, such treatment is commonly very successful, for this form of disorder occurs in subjects of the most robust constitution, in whom therefore the effects of disease are most readily shaken off.

Asthenic inflammation occurs in persons, the tone and real strength of whose vascular system is low (§ 116, 123), and whose blood (generally speaking) is poor (§ 207). The pulse is not always affected; but when it is so, it is in frequency rather than in strength or firmness; the fever, if there be any, is of a slight remittent, or low character (§ 442, &c.). The products of the action are either scanty, or of a cacoplastic or aplastic character (§ 451); or the effusion may be chiefly watery, the inflammation differing little from flux and dropsy.

478. The terms *acute*, *subacute*, and *chronic*, applied to inflammation, properly relate to its duration; but they are often used in the sense which I have given to sthenic and asthenic. *Acute* inflammation may be, and commonly is, sthenic; but it is by no means always so: its distinctive character is, that it tends to a speedy termination of some kind or other. It may end in resolution, effusion, suppuration, or gangrene, in a period varying from a few days to three weeks. An inflammation lasting above the latter period is termed *subacute*, and if protracted beyond six weeks is properly called *chronic*. Very commonly, inflammation is acute because it is severe or sthenic, its intensity leading to a speedy result: but asthenic inflammation is often also short in its duration; whilst chronic inflammation sometimes presents a good deal of the sthenic character (§ 477). Acute inflammation, when at all extensive, is attended with considerable fever and constitutional disorder. With subacute inflammation the fever is less, and may even be absent. In chronic inflammation there is rarely much fever, and when present, it is of a remittent or hectic kind (§ 444, 471).

The products of acute inflammation are commonly so copious as to be distinct in character, being either coagulable lymph, pus, or inflammatory mucus. In subacute inflammation the products are often of intermediate nature, as instanced in purulent lymph, curdy matter, and tubercle in some of its forms. In this, as in asthenic inflammation, the more they are in quantity, the less likely they are to become well organized.

479. Chronic inflammation may originate in the acute or subacute forms, the vascular obstruction and excitement persisting in the part, even after some of the results (§ 445, formerly called terminations) of inflammatory action have been produced. Its general character is asthenic; but there may be considerable determination of blood and local excitement. Its effect in disturbing the functions, both of the part which is its seat, and of other parts, is much less prominent than is the case in acute inflammation; but its duration causes a more serious and lasting alteration of structure. The matter effused by serous membranes in chronic inflammation is always either cacoplastic or aplastic; hence, dense and contractile adhesions, or patches of fibrocellular or semi-cartilaginous matter, cirrhosis, grey miliary tubercle, curdy and yellow tuberculous matter, are amongst its common products.

Mucous membranes discharge muco-purulent, or curdy matter, and the more complex membranes of this class become thickened and sometimes even ulcerate. Sub-mucous textures become the seat of deposit, which, in becoming organized, often contracts, forming strictures in mucous passages. These strictures, by obstructing the passages, sometimes lead to dilatations above. In glands and other complex textures chronic inflammation causes consolidation and induration, and the hardened substance often afterwards contracts and effects the obliteration of connected texture, as in the changes in the lungs, liver, and kidney, inaptly designated by the name cirrhosis.* Sometimes the indurated parts become softened, from the pressure on their vessels (§ 463), as in softening of the brain, or they undergo a process of irregular suppuration and ulceration, as in the excavation of the lungs after chronic inflammation. As was noticed regarding congestion (§ 311), so it may be added of chronic inflammation, that the hypertrophy or excessive deposit of nutritive material is irregular, more in some textures than in others, generally abounding most in the interstitial cellular or filamentous tissue, which then presses on the vessels and other textures, and so often causes their atrophy and partial obliteration. Chronic inflammation in the cartilages ends in caries and ossification: in the bones also it causes caries or exostosis, just as in the skin and other compound textures it leads to induration as well as ulceration. The production of these apparently opposite results by the same process, inflammation, is not paradoxical, when the compound character of that process is borne in mind, and also the diversity that is due to the different proportions of its elements and products. Chronic inflammation exhibits these opposite results the more strikingly, because its effects accumulate in consequence of its long duration; the hypertrophy arising from one of its elements (determination of blood) increases in the immediate neighbourhood of atrophy and ulceration, the results of another of its elements (vascular obstruction).

* Mr. Gulliver describes the consolidation of chronic pneumonia as characterized by "dark exudation corpuscles," pale exudation corpuscles being the chief objects in red or acute hepatization. It appears, however, that these corpuscles are not dark from colour, but merely from opacity, as pus and tubercle are; and they bear a further resemblance to this last product in their irregularity, and in shape, size, and composition, being of various forms, and consisting of molecules, generally without a nucleus, and often without envelop.—Notes to Dr. Boyd's "Vital Statistics," Edin. Med. and Sur. Jour., July, 1843.

480. *Congestive* inflammation is that in which the accumulation of the blood in the vessels of the affected part, and retardation of its movement, predominate over the determination of blood. Hence it is commonly asthenic in its character (§ 477), and generally originates from causes that produce congestion in the first instance (§ 403), the reaction which converts this into inflammation being imperfect or partial. Its symptoms are less prominent than those of more active inflammation, and partake more of the character of those of congestion. Thus there may be little pain, heat, fever, and other signs of irritation or increased action; but the redness (where visible) is more marked and deeper than usual, and if the affected organ be very vascular, (as the liver, lungs, and kidneys,) the swelling may be considerable. Congestive inflammation is usually subacute or chronic, not tending to speedy results; but a kind of flux or dropsy may occur early, as happens from congestion (§ 375). So, too, the solid effusion which follows on it is generally cacoplastic, like that of congestion (§ 311); hence the consolidations or indurations arising from it are often of a dense indolent kind, tending to contract, or to degenerate still further into aplastic matter, (tubercle.) The inflammation of the lung supervening on disease of the heart, on bronchitis, and on asphyxia, is generally congestive; and so is inflammation of the liver from all varieties of cause.

481. *Phlegmonous* inflammation is exemplified in the phlegmon, furuncle, or boil of the integuments. Its chief character consists in its being abruptly circumscribed by an effusion of solid lymph, which brings the inflammation to a termination, either by suppuration, or by slow subsidence, as in the case of blind boils. A highly fibrinous condition of the blood (§ 195) contributes to render inflammation phlegmonous; but this form of inflammation is commonly exhibited by cellular and parenchymatous textures. The type of phlegmonous inflammation is usually sthenic (§ 477); and even where it advances to suppuration or sloughing, it defends the body against the noxious influence of the pus and dead matter. Hence the fever is inflammatory (§ 442), and the local pain, irritation, and heat, are considerable.

482. *Erythematic* or *erysipelatous* inflammation is contrasted with phlegmonous, in its tendency to spread, in consequence of its not being attended with the effusion of plastic lymph. In its severe forms, it is accompanied by much redness, pain or smarting,

heat, and swelling; the effusion is chiefly serous, or sero-purulent, and often raises the cuticle in blisters. In its worst kinds it terminates in diffused suppuration, sloughing, or gangrene. The fever is also of a lower type (§ 443) than in phlegmonous inflammation; being attended by great weakness, disorder of the secretions, foulness or dryness of the tongue, delirium, and confusion or dulness of the senses; and in the worst cases, the fever becomes typhoid, with stupor, muttering delirium, dry brown tongue, sordes on the teeth and lips, slight convulsive startings of the limbs, (subsultus tendinum,) fœtid or suppressed excretions, and sinking.

These adynamic or typhoid symptoms indicate the presence of something more than a mere form of inflammation, and that something must be considered to be a poison. It is probable that this poison is sometimes communicated as an infection (§ 93); for persons living in the same room, or having had much communication with a patient suffering from erysipelas, are more frequently attacked than others; but it is also pretty certain that bad ventilation, and a crowded unclean state in surgical patients, are capable at any time of rendering common inflammation erysipelatous; this effect is also much promoted by unknown epidemic conditions of the atmosphere (§ 89). The most probable hypothesis that can be formed regarding this matter is, that under certain circumstances the products of inflammation become poisonous; and capable of acting (as many animal poisons do) as local irritants and general sedatives or depriments; that they then modify the character of the inflammation and depress the whole vital powers, (as we have found pus and gangrenous matter to do, § 471, 475); and that these effects, and the general and local reaction set up against them (§ 17), lead to the various degrees and forms which erysipelatous inflammation and its accompanying fever are found to present. The same morbid matter, being then transferred by any of the three modes of infection (§ 94) to other persons may convert previously existing inflammation into erysipelas, or if strong enough, may develop it anew in the body. The fact that patients often *sicken* with fever, (rigors, vomiting, headach, quick pulse, delirium, &c.) before the erysipelatous inflammation appears, is a sufficient proof that the poison acts on the constitution as well as on a part; and the fact that weakly persons, and those with previous structural disease, (especially of the kidneys,)

suffer most from the effects of erysipelas, shows the essentially depressing operation of the poison. In several cases of the worst forms of erysipelas, I have found pus globules in considerable numbers in the blood of parts remote from the affected textures; this corresponds with the observations of Mr. Gulliver (§ 462). This seems to suggest that pus may be the poisonous matter that sets up the mischief; but although it is highly probable that these pus globules do possess the septic tendency formerly noticed as belonging to foul kinds of matter (§ 462, 3), yet it is likely that the poison of erysipelas wears a more subtle form, spreading itself in solution or even in vapour, as illustrated by the pernicious properties of the liquor puris, and its fœtid odour (§ 470, 472).

Some asthenic inflammations of mucous and serous membranes and of internal organs exhibit many of the constitutional effects of the worst forms of erysipelas; they sometimes prevail when this disorder is epidemic, and may be traced to the same infection. This is especially the case with puerperal metritis and peritonitis, erysipelatous tonsillitis and laryngitis, and suppurative phlebitis.

483. *Pellicular* or *diphtheritic* inflammation of mucous membranes has some affinity to the erysipelatous, being diffused and spreading, generally asthenic, and accompanied with a low kind of fever. It is attended with more soreness than pain, little swelling, and a deep redness, which is early obscured by the characteristic film of grayish or dirty white albuminous matter, which is exuded on the inflamed surface. Patches of this kind often occur on the tonsils in sore throat, and have been commonly mistaken for sloughs. In certain epidemics, often connected with scarlatina, a diphtheritic inflammation affects the whole throat, and sometimes extends to the trachea and air tubes, the mouth, the gullet, and to more or less of the alimentary canal. The films of lymph thus effused are often fœtid, apparently from incipient decomposition, which is promoted by their exposure to air and moisture in the throat and air passages. As in the case of diffused suppuration and gangrene, this tendency of the results of inflammation to putrefy is at once a sign of the low condition of the vital powers, and a cause of their further depression.

The exudation of lymph instead of the mucus or purulent mucus more commonly effused, I am disposed to refer to the inflammation affecting the submucous cellular tissue, and to its being

at the same time diffused like erysipelatous inflammation. Deep-seated inflammation of a more sthenic character is circumscribed by the effusion causing a thickening of the membrane, as in laryngitis; but the matter effused by diphtheritis, although fibrinous, is thin enough to transude through the mucous membrane on whose surface it concretes. The thinness of the mucous membrane of the air passages in children facilitates such transudation in their deep-seated inflammations: hence, at an early age, all such inflammations may cause an effusion of fibrinous matter, as we find exemplified in croup. So, too, the extreme tenuity of the mucous lining of the smaller divisions of the air-tubes makes the exudation of fibrinous matter a common result in pneumonia and some kinds of capillary bronchitis. This is exemplified in the ramiform moulds of the bronchial tubes sometimes expectorated. Similar skinlike exudations are occasionally passed from the intestines after the irritation of calomel or other strong purgatives, and in some cases without any such irritation. I have had several patients under my care who from time to time pass from the bowels a quantity of shreds like white kid leather, without any symptoms of active inflammation: congestion seems to be a chief cause in these cases (§ 308).

Various asthenic inflammations of the mouth and throat seem to be capable of causing a fibrinous exudation, resembling that which is produced by mercurial action, and that which is seen in the aphthous mouth and throat of adults, common towards the fatal termination of various chronic diseases. Recent microscopic observations have proved that in some of such cases at least, the film consists chiefly of a confervoid vegetable. I ascertained this to be the case with a remarkably white curdy coating on the fauces and gums of an aged female, who was under my care in the hospital in July 1847; the matter was almost totally composed of the jointed tubes, and brilliant sporules and granules of a parasitic growth. The aphthæ of children are somewhat different, being vesicular elevations of the epithelium, with or without an albuminous film underneath.

484. *Hæmorrhagic* inflammation is entitled to be considered as a distinct variety. In most inflammations, there are slight extravasations of blood; but sometimes there is so much colouring matter in the inflamed texture and in the products effused, that it may be difficult at first to say from the appearance whether the

disease is a hæmorrhage or an inflammation. These inflammations I have found to be asthenic; often the subjects were scorbutic, or affected with purpura; and, as I have stated with regard to the latter disease (§ 358), there has been distinct evidence of imperfect action of the liver and kidneys. Thus I have several times met with hæmorrhagic pleurisy and pericarditis in conjunction with cirrhosis of the liver, and Bright's disease of the kidney. An altered condition of the colouring matter (§ 186) of the blood is perhaps more concerned in causing this result than a deficiency of the fibrin, to which it is commonly ascribed: in fact, this is found to be more or less in excess as in other inflammations, but very probably it may be defective in its usual contractile property (§ 203).

485. *Scrofulous* inflammation is decidedly asthenic, and exhibits many deviations from the common form of inflammation. It is well exemplified in the lymphatic glands, one of its most common seats, and within the reach of direct observation. These glands, in common inflammation, become very painful and hot, as well as swollen, and the inflammation tends soon either to resolution or to suppuration. In scrofulous inflammation, on the other hand, the glands swell to a great size; and often the deep redness extends to the surface, but with little pain or heat; and the swelling remains for a very long period without either resolution or suppuration, and is little influenced by antiphlogistic remedies. Sometimes the swelling looks very red, and seems to suppurate, so that distinct fluctuation is perceived, but afterwards the skin becomes wrinkled, and the swelling subsides. When it does burst, or is opened, the pus is serous and curdy, or mixed with matter of a soft cheesy consistence, (soft tuberculous matter); and a deep ulcer with a narrow orifice (fistula) is left, which is indisposed to heal. The microscopic characters of scrofulous matter are a paucity, and irregular form, of the pus globules, and a great predominance of granular matter, loose or coherent in clots, and the presence of oil globules in considerable numbers. These characters at once explain both the aplastic and the indolent properties of the matter; they show why it is destitute of the organizability of fibrin, and of the cell developing and osmotic attributes of pus (§ 461). In proportion as it gets older, as in *cold abscesses*, the pus globules become collapsed, and the liquid partly absorbed, the matter acquires a cheesy or putty-like consistence,

and in time undergoes a further change into fatty matter and phosphate of lime. The kind of inflammation from which this has originated occurs in persons who possess what is called the *scrofulous diathesis* or *constitution*.

The scrofulous diathesis is merely a term employed to designate a state of the body in which scrofulous inflammation and malnutrition are apt to occur. It has been generally stated that this diathesis has certain outward marks, by which its existence may be recognised independently of the actual occurrence of disease. Thus a relaxed state of the muscles, a soft transparent skin, a fair or pale complexion, with partial patches of a peculiar pink or purplish redness; a pearly whiteness of the eye and teeth; a tumid upper lip; fair or reddish hair; large and weak joints, precocity of intellect, and some other analogous signs, have been described as characterizing the scrofulous diathesis. But such appearances may be presented without any manifestation of scrofulous disease; and still more frequently, scrofulous disease is induced in persons quite destitute of these characteristics.

More constant concomitants of the scrofulous disposition (although they sometimes occur without scrofula) are, various signs of weak circulation and imperfect nutrition, such as cold extremities; weak, but easily accelerated pulse; small development of muscles; uncertain digestion and irregular excretion; and slow or defective healing of wounds. The circumstances which most favour the production of the scrofulous diathesis are also influences of a weakening kind, especially when these are long continued, such as poor or insufficient nourishment, especially in childhood or youth; cold and damp situations, or defective clothing; long confinement in close, ill-ventilated habitations; long-continued illness, especially from eruptive or typhoid fevers; and prolonged and aggravated disorders of the digestive organs. Scrofula is also, in a marked degree, an hereditary affection (§ 36); and mere feebleness of constitution in parents, whether original or from disease, or from indulgence in excesses, or from advanced age, often develops a disposition to scrofula in children.

In persons of the diathesis now noticed, inflammation frequently runs a course, and leads to results which are different from those that ensue in a healthy subject. Commonly the inflammation is more asthenic (§ 477); often it is more subacute or chronic (§ 479) than usual; but in all cases, its solid products are not euplastic

(§ 450), as in healthy persons; but either cacoplastic (§ 452) or aplastic (§ 453), according to the prevalence of the scrofulous constitution, the texture affected, and the quantity of the inflammatory product thrown out. Where the scrofulous diathesis is most developed—where the texture inflamed is an internal one, and so placed as not to be able to discharge freely externally—and where the product of inflammation is most copious,—there the deposit will be most aplastic, consisting of scrofulous pus or yellow tubercle, devoid of regular structure, and wholly insusceptible of organization; and being unfit for absorption, it then operates as a foreign body, irritating, obstructing, and compressing the adjoining parts, in various ways detrimental to their functions and structure. Thus arise tuberculous or scrofulous deposits and abscesses in lymphatic glands, in bones, cartilages, and in the connected cellular textures, tuberculous infiltrations in the lungs, and deposits in serous cavities. Where the scrofulous diathesis is less pronounced, and the inflammatory effusion less copious and more gradual, the result may be a cacoplastic product, susceptible of only a low organization; as grey, miliary, and tough yellow tubercle; cirrhosis, atheroma of arteries, fibro-cartilage, and other degraded living solids. These have been already noticed (§ 453, 454), and will again come under consideration as products of altered nutrition. The aplastic tendency of inflammation in scrofulous subjects is sometimes manifest in other forms in different textures. Synovial membranes of joints are softened into a brownish pulp, (Brodie); articular cartilages and the cornea ulcerate, from absorption predominating over nutrition (§ 466); the integuments of the face and other parts inflame in small cutaneous tumours or tubercles, which ulcerate, and for want of plastic material, the ulcers become phagedenic and spreading, and destroy the nose or adjacent parts, as in lupus.

It seems, then, that the most marked peculiarity of scrofulous inflammation is, that it degrades or arrests nutrition, by supplying a material that is little or not at all susceptible of organization. This leads us to inquire what is the condition of the blood in scrofula; the answer is found in the fact ascertained by Andral and Gavarret, and before mentioned (§ 454), that there is an excess of fibrin (§ 195), and a deficiency of red corpuscles (§ 185). The fibrin is, however, defective in that finely fibrillated structure that is indicative of plasticity.

487. The poisons of *gonorrhœa* and *syphilis* excite inflammations still more peculiar in their phenomena and course. *Gonorrhœal* inflammation chiefly affects the genito-urinary passages and the conjunctiva. It is generally acute, and results in the secretion of an opaque sulphur-coloured pus, which is capable of communicating the disease. Sometimes it affects the testicle also with acute inflammation, and the joints with a more chronic kind, constituting then gonorrhœal rheumatism.

Syphilitic inflammation exhibits great variety in the sites it attacks and in the effects it produces. Locally, the syphilitic poison excites a papula, or small tubercle on any delicate membrane it touches, which, ulcerating, then forms a chancre. As the matter is absorbed from this, it causes inflammation with great pain and swelling of the neighbouring lymphatic glands (bubo), which may pass on to suppuration. These are primary inflammations, and of an acute character. When thoroughly in the system, it may excite secondary inflammations; sore throat, generally of an asthenic type, and tending to ulcerate; and a great variety of affections of the skin, which differ greatly in their character, according to the vigour, &c., of the subject. These often leave a peculiar livid or copper-coloured stain in the under layer of the epidermis, which obviously arises from an extravasation of some colouring matter from the blood, and probably implies a change in it. The periosteum and bones are also often attacked with syphilitic inflammation; and painful nodes, exostoses, suppuration, and caries, result. The iris is sometimes affected with acute inflammation, leading to an effusion of lymph, which may endanger the sight if not arrested in time.

TREATMENT OF INFLAMMATION.

488. We have found inflammation to be an essentially complicated process, consisting of several constant elements, to which are frequently added other accidental ones, which then further increase the complexity of the disease. A proper knowledge of these several elements, and of the means which best remove or counteract them, separately and in combination, forms the best guide to the rational treatment of inflammation, and supplies a safe clue to the comprehension of the confused and paradoxical assemblage of agents which experience has proved to be *antiphlogistic remedies*. As we have not time to discuss in full detail all the constituent elements and results of inflammation in relation to treatment, we propose simply to enumerate them, with a reference to the text, that affords a more full explanation, and then to express in a tabular view the remedies that may be best employed for each. This table therefore comprises an enumeration of the different agents used in what is termed the *antiphlogistic treatment*.

489. *Constituents of Inflammation.*

From operation of exciting cause.

- Congestion (§ 403, 407),
  or
- Nervous and vascular irritation (§ 402, 408).

Local elements of inflammation, (essential.)

- Determination of blood towards the affected part (§ 409, 419).
- Obstruction of the vessels most affected (§ 410, 419); by atonic enlargement of the capillaries (§ 414); by impaction of blood corpuscles within them (§ 415).
- Distension of arteries and capillaries BEHIND the obstruction (§ 420), causing effusion (§ 423) of serum, lymph, pus, &c. (§ 427).
- Emptiness of veins BEYOND the obstruction (§ 427), inducing increased absorption (§ 467), and thence softening, &c.
- Impeded or arrested circulation AT the obstruction (§ 418), causing a reduction or abolition of vital properties (§ 273), hence the death of the structure and its removal by ulceration (§ 466) and suppuration (§ 427), or by the decomposition of gangrene (§ 473).
- Increased circulation of blood AROUND the obstruction (§ 410), causing exaltation of vital properties there (§ 421, 333); hence spasm (§ 113), pain (§ 135), sympathetic irritations (§ 149), increased secretion (§ 159), &c.

Constitutional effects of inflammation, (not essential.)

- Extension of the excitement to the heart and arteries (§ 440), causing inflammatory fever.
- Change of composition in the blood, by increase of fibrin furnished by the inflamed part (§ 438), and in consequence of diminution of excretion attending the inflammatory fever (§ 441).
- Exhaustion ensuing after the excessive excitement (§ 116), or in consequence of effusion (§ 459, 470).
- Depression, sometimes with local irritation, caused by the presence of pus or gangrenous matter in the blood (§ 470, 475); and retention of excrementitious matter (§ 443).

490. TABULAR VIEW OF THE CONSTITUENT ELEMENTS OF INFLAMMATORY DISEASE, WITH THE REMEDIES ADAPTED FOR EACH.

CONSTITUENTS OF INFLAMMATION.	ANTIPHLOGISTIC REMEDIES.	
1. Congestion	Astringents; stimulants; evacuants; (315, *et seq.*)	For incipient inflammation.
2. Irritation of nerves	Narcotics; counter-irritants (§ 137, 155).	
3. ——— of vessels	Sedatives; derivatives; evacuants; (§ 342, *et seq.*)	
4. Determination to the part	Cold and other sedatives; derivatives; evacuants	For local inflammation.
5. Obstruction in the part: —— by atonic enlargement	Same remedies as for 1. Congestion	
6. —— by adhesion of corpuscles	Remedies uncertain; attenuants? (§ 217); sedatives? (§ 416)	
7. Distension of vessels	Counter-pressure; blood-letting; derivation (§ 319)	
8. Effusions	Evacuants; derivatives; operations; sorbefacients?	
9. Increased absorption	No direct remedies known; stimulants; diminishing atmospheric pressure on the part?	
10. Impeded circulation in the part	Moist heat and other stimulant applications	
11. Increased circulation around	Remedies for 4. Determination, (see above)	
12. Excitement of the heart	General blood-letting and other evacuants; sedatives (§ 115)	For general derangement, (inflammatory fever.
13. —— of the arteries generally	General blood-letting and other evacuants; relaxants, (antimony, &c. § 122); salines	
14. Change of the blood: —— by increase of fibrin	Blood-letting and other evacuants; (§ 214); mercury; salines; low diet, cod-liver oil?	
15. —— by diminution of the excretions	Eliminants; alteratives (§ 172, *et seq.*)	
16. Exhaustion	Stimulants and tonics (§ 119, 124)	For results of inflammation.
17. Depression from poison in blood	Stimulants; antiseptics; evacuants; (§ 260)	
18. Effused products of inflammation	Eliminants; attenuants; alteratives; sorbefacients? stimulants; pressure, and friction	

491. My limits will not allow me to do more than offer brief comments on these principles of treatment, and to exemplify them by a few of the results of my own experience; and it is an important corroboration of the truth of these principles that they expressly indicate the advantages that are attained from the use of the various remedies which have been found effectual in the treatment of inflammation, they suggest the peculiar uses of them respectively, and they open to us a path of inquiry in pursuit of others which are yet wanting.

Remedies for incipient Inflammation.

1. *Congestion.* The efficacy of topical astringents and stimulants in removing the congestion which precedes inflammation, is illustrated in the effect of a strong solution of nitrate of silver or sulphate of zinc in curing conjunctival ophthalmia, and of the same agents, of powdered alum (Velpeau), and of capsicum gargles, in curing an incipient sore throat. But as it is with congestion (§ 317), so also is it still more striking with the congestive stage of inflammation, if it be extensive, long established, or already complicated with determination of blood, astringent applications can never restore the lost tone, nor clear the obstruction of the vessels; and therefore can only operate as irritants, and aggravate the inflammation under these circumstances; it is then that evacuants, derivatives, and even blood-letting, are more appropriate. The utility of these measures has been alluded to under the head of congestion (§ 318); but their employment is commonly even more necessary in the congestive stage of inflammation, inasmuch as this tends to further and worse results. A strong purgative and diaphoretic, if given early enough, may suffice to remove an incipient inflammation; but if this inflammation be extensive, and more especially if the subject be plethoric, the proper remedy, even at this stage, is blood-letting, local or general, according to the situation and extent of the mischief.

492.—2 and 3. *Irritation of nerves and vessels.* The irritation of the nerves, which we have found to constitute a part of the commencement of some inflammations (§ 403), is so closely followed by irritation of the vessels, that the same remedies are adapted to be serviceable for both. The efficacy of a large dose of opium in incipient inflammation exemplifies the power of narcotics to subdue the nervous irritation, and such remedies are the

more indicated when pain, spasm, and other signs of excited nervous function (§ 151), predominate. On the other hand, when heat and redness prevail, the disturbance is more in the vessels, and the appropriate remedies then are sedatives, such as the application of cold and saturnine lotions to the part, and the employment of various evacuants and derivatives, which draw the blood away from the distended vessels. Counter-irritants or revulsives of the most speedy operation, such as heat, dry and moist, mustard poultices, and other stimulating applications, made near the affected part, seem to act both on the nerves and vessels, and so are powerful means for subduing the irritation which leads to inflammation. The effect of these applications on nervous irritation is in proportion to the sensation which they produce; when pain or other sign of nervous excitement predominates, a heat almost scalding or burning, or stimulating agents which cause severe smarting, prove most effectual. On the other hand, when the vessels are most excited, as evinced by heat and redness, (if visible,) counter-irritants or revulsives which act extensively rather than intensely, are of more avail; as for instance, a general or partial hot bath, or a large poultice, or fomentation, made more stimulant by various additions.* Purgatives and other evacuants are still indicated here, on the same principle. Emollient and demulcent agents, when they can be directly applied, often soothe an inflamed surface, at the same time by promoting the natural secretion, by removing irritating matter which may have helped to cause the inflammation, and by reducing the acrimony of the morbid discharge (§ 455).

Remedies for established local Inflammation..

493.—4. *Determination to the part.* This, with the next condition specified, *obstruction in the part,* is only a further result of irritation of the vessels; but it is convenient to speak of it here as a constituent of established inflammation. It is to be opposed by the same remedies as those just mentioned as appropriate for

* A great improvement in the facilities for fomenting parts with hot water, with or without stimulating additions, is supplied by the various water-proof fabrics, such as India rubber cloth, oiled silk, or gutta percha sheet, which being applied as a cover, prevent the rapid escape of the heat and moisture. I have for many years adopted these auxiliaries with great advantage, especially where a prolonged effect is desired. The India rubber epithems, called piline and spongio-piline, introduced into this country by Mr. Markwick, answer the purpose very well.

vascular irritation, and those formerly noticed as suitable for simple determination of blood (§ 342, *et seq.*); but in consequence of belonging to a disease which is more enduring and serious, the determination attending inflammation requires a bolder employment of the measures. Of sedatives none is so effectual under these circumstances as the application of cold; it promotes the contraction of arteries (§ 120) more than any other agent. It is thus that ice and cold lotions prove salutary in reducing active inflammation when they can be properly applied, as they can if the affection is external: in some internal inflammations the cold may be still made to reach the organ affected, as when a bladder of ice is applied to the head in meningitis, and when small pieces of ice are slowly swallowed in gastritis. Cold will do harm instead of good in inflammation, either if it does not reach the enlarged arteries through which the increased flow takes place (§ 326), or if it is not sustained long enough to prevent the effects of reaction (§ 79), by which the arteries again become enlarged so that the determination is renewed. For these reasons, external cold applications are injurious in most internal inflammations, and if not steadily regulated, they may prove so in other cases likewise.

Warmth and other derivant influences addressed to parts more or less remote from the vessels which are the channels of determination are very serviceable aids in the treatment of this element: partial or general warm baths, hot poultices, &c., operate in this way. Diaphoretics, such as antimonials, which equalize the circulation without stimulating, are also beneficial, because they relax the cutaneous vessels generally, and thus derive to the whole surface. So too we noticed (§ 345) that purgatives and diuretics operate as derivatives as well as evacuants; and that blood-letting is the most effectual of all (§ 346). Change of posture, by elevating the part inflamed, may also be mentioned among the means which counteract determination of blood.

These different measures, which may suffice in simple determination, may nevertheless prove insufficient for that attending inflammation, chiefly because their influences cannot easily be sustained for a considerable length of time. Various agents are therefore employed to produce a more enduring derivation or revulsion, as well by acting as counter-irritants, as by exciting artificial inflammations in other structures and parts. To this

class belong blisters, mustard poultices, applications of tartar emetic, croton oil, strong ammonia, mineral acids, some of the essential oils, heat above 120° Fahrenheit, &c.: the amount of inflammation which is excited by their employment varies according to the manner and duration of their application. As these fulfil several distinct indications in the treatment of inflammation, they will again come under our notice.

494.—5 and 6. *Obstruction in the part by atonic enlargement of the capillaries, and by adhesion of the white corpuscles and accumulated impaction of the red.* These are classed together, because they jointly combine to keep up the partial obstruction which is characteristic of inflammation. The atonic enlargement of the capillaries may be said to be included in the congestion before noticed; but it stands here as a part of established inflammation, which is different from mere congestion (287). The remedies to be addressed to it are, however, the same in both cases; but here they generally occupy a subordinate place, unless they fulfil other indications. There are, however, a few cases in which treatment for congestion, even by stimulants, proves effectual in curing inflammation. Catarrhal inflammations of mucous membranes are sometimes removed by a highly stimulant treatment consisting of the administration of wine, spirits, or ammonia. It is probable that then the accelerated circulation excites the dilated capillaries to contract, and that the obstruction is thus swept away. This treatment when effectual generally causes sweating and a copious deposit in the urine; but these seem to be as much effects as causes of the improvement, for sweating by other means is not so serviceable. This mode of treatment, however, is hazardous, for it acts by increasing the flow of blood, and if this fail to remove the obstruction, it will surely aggravate the inflammation.

But the most constant and important part of the obstruction of Inflammation is due to the unusual impaction and stagnation of red and white corpuscles within the inflamed vessels; and as it is this especially that establishes inflammation, and is the cause of its most serious results, it would be very desirable to find some remedial influence capable of counteracting it. Unfortunately, however, we are not acquainted with any direct means by which we can check the aggregation and cohesion of the pale and red corpuscles, or dissolve their union. As these little bodies are in

osmotic relation to the blood liquor, the desired remedies must be sought among the medicines which affect the blood; and it might be surmised that the neutral and alkaline salts possess this virtue. They certainly are able to dissolve fibrin, and become neutralized by it—Denis has shown that the fibrin of venous blood is dissolved by digestion with a solution of nitre, and reduced to the condition of nonplastic albumen—Mr. Gulliver finds that the neutral salts do tend to keep the blood corpuscles from becoming adherent. The efficacy of carbonate of potash as an antiphlogistic remedy has been much vaunted by Sarconi and other Italian writers; but this does not appear to have been confirmed by universal experience. Some experiments of Mr. Blake's (§ 214) seemed to indicate that salts of potass, injected into the veins, promote the coagulation and stagnation of the blood instead of preventing them. If the chemical view of the augmented adhesiveness, already propounded (§ 417), be correct, it may be inferred that such measures would be most likely to be effectual in obviating it, as would tend to interrupt the hyper-oxidation of the plasma; and as this must depend very much on the flow of arterial blood which brings the oxygen to the part, we are led to a new reason for the advantageous operation of depletion, derivation, sedatives, and other influences that reduce the force of the local and general circulation, as well as the richness of the blood which supplies the inflammatory material. Whether any direct deoxidizing agent can be made to conduce to the same end is a question worthy of careful investigation; most medicines calculated to produce the result are objectionable on account of their stimulant or heating influence, as for example, alcohol and oils, and in a minor degree, sugar and starch. The deoxidizing agent should possess no such property, either before or after its own oxidation. May not the antiphlogistic operation of antimony and mercury owe something to their fulfilling this condition? Their virtue certainly is chiefly confined to their protoxides and proto-salts. Analogous preparations of other oxidizable metals, which have no stimulant or injurious action, and sulphurets of metals and alkalies, have formerly enjoyed some repute as remedies in inflammation, and possibly may deserve yet further trials. I have myself found that the most efficacious remedy for certain cutaneous inflammations, such as acne simplex and rosacea when in an excited state, is a weak solution of sulphuret of potash used as an outward application; and sulphuretted waters are well known to be useful soothing agents

in irritable conditions of the alimentary canal—possibly owing to some operation of an analogous kind. There is, however, one important fact that is worth bearing in mind, while the influence of sulphur compounds is under consideration. It is that albumen contains more sulphur in its composition than fibrin. There is no doubt that fibrin can be changed into albumen in the living system as well as the converse, and possibly the mere presence of a superfluity of sulphur, under certain circumstances, may determine the change. As the presence of a superabundance of white corpuscles, and an augmentation of the fibrinous constituents of the blood are constantly found to occur simultaneously, it seems highly reasonable to seek agents capable of influencing the condition of the white corpuscles, amongst such as are known to possess chemical power over fibrin.

495.—7. *Distension of Vessels.* This condition, which has been already explained as the result of determination of blood into congested and obstructed vessels, is another highly characteristic constituent of inflammation. Distension sometimes occurs in congestion (§ 306); but then it chiefly affects the veins; here it is in the small arteries, and in all those parts of the capillaries that are on the arterial side of the obstruction. This in some degree accounts for the greater degree to which it attains, and the larger amount of effusion and other changes that result from it. But the peculiarity of inflammatory distension and of its consequent effusions cannot be well understood without keeping in view that concentration or exaggeration of influence exerted by the red particles on the liquor sanguinis, when, on their accumulated and impacted masses, a strong current of arterial blood is continually impelled (§ 416). This view, too, suggests that the most effectual means of relieving the distension, must be the speedily lessening either the determination of blood or the obstruction. The measures for reducing the determination need to be of the strongest kind, such as blood-letting and free derivation or evacuation; for the arteries which are its seat are closed at their capillary ends, and must, therefore, be drawn upon from behind, and by influences which reduce the pressure in the arteries generally. When there is considerable determination of blood, the distension which it causes will not be relieved without drawing blood either from the enlarged vessels themselves, or from other parts, in sufficient quantity to reduce the heart's action and the general arterial pressure.

There are other less powerful agents that afford some relief to

the distension of vessels in inflammation. External pressure, carefully equalized, will sometimes do it, as instanced in the effect of well-applied bandages and strapping on wounds. Fluid pressure, as proposed by Dr. Arnott, by means of quicksilver, or of the slack air-cushion applied under a bandage, is capable of being made still more useful in various external inflammations, because its own equality ensures its proper application. It is very probable that a part of the efficacy of poultices depends on the soft and uniform pressure which they produce on the inflamed vessels. But poultices, fomentations, and other analogous applications of heat and moisture, certainly relieve distension also by relaxing the solid fibres, and by promoting the exudation of the watery parts of the blood.

496.—8. *The effusions from the vessels,* although attended with augmented vital actions and cell-formation, are partly caused by continued impulsive distension. They may therefore be prevented or lessened by means which reduce this distension. In severe cases of inflammation, effusion is the natural mode in which vessels are relieved of their load, and should not be opposed; and we have just pointed out that poultices and fomentations give relief by promoting this result. If the effusion is outwards, as when furnished by a mucous membrane, it may not be necessary to check it, except so far as it is interfering with the functions of the part. Alkaline medicines often give relief by attenuating a thick secretion and so leading to easier effusion; acids and astringents are the remedies that check it when it is too profuse, but blisters and various general evacuants should be employed at the same time, otherwise the inflammation may be increased; this corresponds with the principles laid down for the treatment of sthenic fluxes (§ 393). When the effusion is into cellular texture, the parenchyma of organs, or a serous cavity, it may seriously interfere with the functions of the part; and it is therefore then important to prevent, restrain, or remove it. Thus, very slight effusion in the submucous cellular texture of the glottis, or into the serous cavities of the brain, may prove fatal; and in the lungs or pleura, it becomes injurious in proportion to its extent. It is doubtful whether we possess any other means of restraining effusion, beyond the employment of the ordinary remedies for determination and vascular distension. It is pretty certain that some antiphlogistic medicines, especially mercury and antimony, do diminish the effu-

sions of inflammation, and promote their absorption; but it is not clear that they do so in any more direct way than by reducing the local and general excitement, or by their evacuant effect. The expressions, "sorbefacient" and "exciting the absorbents," hypothetically ascribe to remedies the power of increasing absorption; but nothing in physiology points to any direct mode by which absorption can be artificially increased. A free action of the excreting organs promotes absorption indirectly, by reducing the distension of the vascular system. Absorption is also promoted by whatever renders the circulation free, without producing excitement or distension;* the return of the vessels to a healthy state is generally attended with more or less absorption of effusions that have been thrown out. It is probable that blisters and other counter-irritant applications made near an inflamed part induce absorption not merely as evacuants or derivants, but also by causing a rapid flow of blood through the adjoining vessels, which facilitates the operation of osmosis, and the removal of effused fluids. Hot fomentations, douches, and stimulant frictions seem to act much in the same way.

There can be no doubt that nature possesses various means of ridding living structures of the products of disease by modifications in that process of cell-formation which constitutes a chief part of healthy nutrition. Most of the solid products of inflammation bear evidence of their connexion with this process. Those from mucous membranes are continually thrown off in a secretion loaded with cells, varying from the standard of those of the natural epithelium, to their morbid modifications in mucous and pus globules. In cellular and parenchymatous structures, when lymph is effused and subsequently dispersed, its removal seems to be effected by a retrograde conversion into disintegrated cells and granules, which gradually disappear. Now in all these processes of cell-formation and dissolution, the fatty element seems to be an essen-

* In my Gulstonian Lectures (Med. Gaz., July, 1841), I adverted to the effect of rapid movement of blood in promoting absorption. Dr. G. Robinson has since illustrated this by some experiments (Med. Gaz., May, 1843). Another influence which probably contributes to the same result is the different density of the fluid within and without the vessels: that within is more dense and saline, and by the law of osmosis, tends to attract to itself the thinner fluid from without. This explains the greater readiness with which thinner effusions are absorbed. Would it be possible to increase absorption by rendering the blood more saline than usual? The thirst experienced after taking salt food seems to be referable to this same cause; and the beneficial influence of salines in inflammatory diseases may be partly due to this mode of operation.

tial ingredient; and as in the healthy removal of superfluous tissue, as in the reduction of the structure of the uterus after delivery, much of the material undergoes degeneration into fat, so these products of inflammation exhibit the same change before they are dispersed. These considerations throw some light on the acknowledged utility of cod liver oil in promoting the removal and dispersion of the products of inflammation. Being absorbed freely into the blood in a highly divided state, it soon pervades the products of disease, and by dissolving the most solid fats and affording molecular centres for numerous separating granules, it promotes the process of softening and disintegration, and thus brings the effused matters within the reach of the processes of absorption and elimination. I believe that there are few cases of prolonged inflammatory disease, in which this agent will not assist in the dispersion of the products of inflammation, and in the re-establishment of healthy nutrition.

There are cases in which it is necessary to give vent to the accumulated effusion by surgical operation; this is illustrated by the incisions or acupunctures made in erysipelas, by opening abscesses, and by paracentesis in empyema, &c. These measures are chiefly required when the effused matter is purulent and little susceptible of absorption, as well as noxious to the system; but sometimes the mere quantity or situation of the effusion, renders the resource of an operation necessary, in consequence of its immediately endangering life by mechanical means, as in acute laryngitis and some cases of pleurisy.

497.—9. *Increased absorption* is manifested in the processes of softening, ulceration, and suppuration. I have endeavoured to explain how absorption is increased in the midst of distended and effusing vessels. The veins and lymphatics are free, and in consequence of the motion communicated to them from the current of the neighbouring and anastomosing branches, they are ready to convey away all the fluids that can pass in through their coats. (Gulstonian Lectures, 1841.) In fact, this is doubtless a provision especially made for the removal of superfluous matter, whether effete or new: but the process becomes injurious and destructive when it predominates over nutritious effusion, and extensively invades the living textures. There is, as we have seen, reason for the notion that textures do not fall a prey to the softening or ulcerative process, unless their vitality is lowered, and their nutri-

tion impaired in consequence of a deficient supply, or defective quality, of blood (§ 466, 7); but inflammation produces these effects differently in different cases. Sometimes local stimulants and general tonics check softening and ulceration by improving the vitality and nourishment of the obstructed part; but they produce the opposite effect if the circulation in the affected part is so much obstructed that it cannot be quickened. Hence, in phagedenic ulcerations, stimulants sometimes check and sometimes aggravate the disease. The increased absorption which is a part of the ulcerative process may be arrested by diminishing atmospheric pressure, as is done when a cupping glass is applied over a phagedenic ulcer; but such an expedient is rarely practicable.

498.—10. *Impeded circulation in the part* has been already adverted to as contributing, with increased absorption, to the processes of softening and ulceration; but its greatest effect is manifested in gangrene, or the complete death of a part. In suppuration, also, the affected part dies, but it is then removed step by step by absorption, or its cells are converted into pus cells, so that its place is occupied by pus, which eventually makes its way to the exterior. Of the few agents that may be named as serviceable in restoring or improving obstructed circulation, heat is the most important. It enlarges vessels, especially arteries (§ 120), and facilitates the passage of blood through them; and although, for this very reason, it is hurtful in sthenic inflammation, and in parts where determination prevails, it is very beneficial in the stages and forms of the disorder in which obstruction predominates so as to endanger the vitality of the part. Hence the utility of hot fomentations or poultices in low forms, or advanced stages of external inflammation. In slight cases, frequent applications of heat and moisture may entirely remove the obstruction, and restore the circulation, and through it the life of the part, although the inflammation may have already caused much effusion. In other cases, when heat does not remove the obstruction, and therefore does not maintain the life of the part, it may nevertheless, by increasing the determination around it, promote its removal by hastening and maturing the process of suppuration, which is the best by which this end can be effected under such circumstances. In a similar way too, heat favours the effusion of lymph, which circumscribes the suppuration and prevents it from spreading or infecting the system. And so also, heat and other stimulating

applications promote the process of separation or sloughing of gangrenous parts (§ 475) when they have entirely lost both circulation and life. These latter effects may also be often promoted by medicines and food calculated to maintain the vigour of the general circulation.

499.—11. *The increased circulation around the obstructed part* is often that constituent of inflammation which causes the most prominent symptoms; heat, pain, tenderness, and other indications of excited function are commonly dependent on it. Determination has been already alluded to as an element of the early stage of inflammation, and the reader is referred to that notice (clause 4) for an account of the remedies with which it is best combated. Determination to the neighbouring vessels is a part of the extending irritation of inflammation, which often sympathetically excites the whole system into fever. Its treatment, therefore, should be of the same character with that which is suited for inflammation with fever.

Treatment of inflammation with fever.

500. The fever excited by inflammation consists chiefly of the constituents mentioned in the table; but it will prove more convenient to notice them here altogether. They are—(12) *Excitement of the heart and* (13) *of the arteries;* (14) *change in the blood by increase of fibrin, and* (15) *by diminution of the excretions.*

The addition of fever to inflammation very materially modifies the treatment. The disorder then to be set right affects not merely the inflamed part, and a few other parts that are in sympathetic relation with it, but the whole vascular system, the blood and the secretions and functions which it supports. The treatment must now therefore be general, instead of being merely local; not because the local inflammation has lost its importance, but because it has become a part of a general disease, which reacts upon and sustains it with such energy that local remedies are only trivial, if they are not absolutely injurious. Thus, when inflammation is backed by febrile excitement of the heart and arteries, the stimulant and astringent antiphlogistic remedies (§ 491) irritate the distended vessels instead of making them contract. What good can local blood-letting do, when there is an excited force behind impelling the blood to the inflamed part more rapidly than the external oozing can remove it? Derivants also

have little power when the tension of the whole vascular system is so much raised. Counter-irritants even prove injurious, by adding another cause of excitement to the system. So, too, narcotics can have no control over fever fully established, but more commonly prove hurtful by exciting the nervous centres, and still further impairing the secreting powers (§ 166). A remedy is wanted that is capable of acting more extensively and generally by reducing the action of the heart and arteries, and by diminishing the inflammatory character of the blood. The most important and powerful agent of this kind is general blood-letting; next to it rank the stronger evacuants, antimony and mercury; and below these in power there are what are called refrigerants and direct sedatives. We proceed to notice briefly each of these antiphlogistic remedies.

501. Blood-letting, if carried far enough, is sure to reduce the action of the heart; for, it may be made to produce syncope. A remarkable fact, first pointed out by Dr. Marshall Hall, is, that in inflammatory disease a much larger amount of blood may be drawn without producing syncope than can be taken during health or in other diseases. The following is Dr. M. Hall's table of the results of his investigation of the tolerance of blood-letting in different diseases. The numbers represent the mean quantity of blood which flows before incipient syncope is induced, the patient being in the sitting or erect posture.—

I. Augmented Tolerance:	
Congestion of the brain	℥ xl—l.
Inflammation of serous membranes	℥ xxx—xl.
Inflammation of synovial membranes	
Inflammation of fibrous membranes	
Inflammation of the parenchyma of organs, (brain, lung, liver, mamma, &c.)	℥ xxx.
Inflammation of skin and mucous membranes (erysipelas, bronchitis, dysentery)	℥ xvi.
II. Healthy Tolerance:	
This depends on the age, sex, strength, &c., and on the degree of thickness of the parietes of the heart; but it is about	℥ xv.
III. Diminished Tolerance:	
Fevers, eruptive and others	℥ xi—xiv.
Delirium tremens and puerperal delirium	℥ x—xii.
Laceration or concussion of the brain	℥ viii—x.
Accidents, before the establishment of inflammation	
Intestinal irritation	
Dyspepsia, chlorosis	℥ viii.
Cholera	℥ vj.

The explanation of the system's increased tolerance of blood-letting in inflammation is, I apprehend, to be found in the increased excitability of the heart and tonicity of the arteries, which maintain a sufficient force and tension to preserve the circulation, especially through the brain (§ 266), even when much blood is lost. In asthenic or atonic diseases, on the other hand, the arteries being lax, and ill-fitted to transmit the blood, a smaller loss is felt, and syncope is more readily produced. The difference of tolerance in inflammations occupying different seats must be referred to the heart's strength and the arterial tone being less augmented in some than in others, and therefore affords indications of the more or less sthenic (§ 177) character of the affection. The quantity of blood in the system affects the heart's action and arterial tension in a similar way; and no doubt a more stimulating quality in the blood may contribute to the same results.

502. The object of blood-letting in inflammation is not merely to produce syncope, or a temporary impression on the circulation, but also a permanent reduction in the excitement of the heart and arteries; this is best effected by employing different modes of blood-letting under different circumstances. Where the inflammation is quite recent, and the fever has not existed long, a moderate amount of blood rapidly taken from a large orifice, or from two arms at once, or even from the jugular vein, will often be sufficient to arrest the disorder. The circulation is thus reduced, perhaps to the extent of syncope; and when relieved of the pressure and of determination of blood, the inflamed vessels soon recover their normal state, or may be then caused to do so by the further employment of subsidiary antiphlogistic measures. The benefit resulting from this mode of blood-letting in recent cases is sometimes very striking, and the cure is effected at a comparatively small expense of blood.

503. But the case is different when an acute inflammation and fever have lasted for two or three days. There is then not merely excitement, but sundry material changes in the inflamed part and in the blood, which tend to keep up the excitement; the inflammation has become established in the part, and the fever in the system; and no brief impression on the circulation can remove them. If in this state a patient be freely bled to fainting, reaction will soon ensue, and renew the fever with increased intensity. Here, therefore, it is necessary to bleed more slowly and to draw

more blood; and instead of promoting the occurrence of syncope by the erect or sitting posture, it is better to keep the patient in an easy recumbent or reclining position, and to watch for the good effect of the bleeding in the softening of the pulse, or the relief of the pain or other distressing symptoms. The actual occurrence of syncope is rather to be avoided than sought, and it may be prevented by loosening the bandage as soon as the lips lose their colour, or the patient complains of feeling sick or faint. Thus practised, blood-letting causes a more lasting reduction of the active elements of inflammation and fever, diminishes the exciting and too fibrinous condition of the blood, and although it cannot repair the structural changes already produced in the inflamed part, it prevents their increase, and puts the structures in a condition that is favourable to the curative efforts of nature and to the further operation of other antiphlogistic remedies. In the more severe and confirmed cases of inflammation it may sometimes be requisite to repeat the blood-letting again and again; the indication for the repetition being the return of incompressibility of the pulse, augmented heat of skin, and a new aggravation of all the prominent symptoms. In all such cases, the advantage of the gradual over the sudden mode of blood-letting is very apparent, for where the reducing influence of the measure is longest sustained, it is found to be the least necessary to resort to it again. In such cases too, cupping or free leeching will often prove more effectual than venesection; giving more relief to the local symptoms and causing less depression to the vital powers.

Another condition in which it is expedient to draw blood largely rather than suddenly is when inflammation is combined with plethora. On the other hand, in anæmic subjects, if blood-letting be at all admissible, the blood must be economized as much as possible; in them therefore early depression from the loss of blood should be promoted by a posture favouring the occurrence of syncope, and this state may be advantageously sustained by the influence of antimony and other like remedies. In some cases connected with anæmia the temporary withdrawal of a portion of blood from the heart and large vessels by means of the process which is termed *hæmostasis*, may prove very beneficial; by ligatures being tightly passed round one or more of the large limbs, a certain quantity of blood may be arrested in them, and for the time withdrawn from the current of the circulation (§ 318); this

expedient is preferable to dry cupping, because it does not spoil the blood that is so arrested to the same extent.

504. After the excitement of the system has been lowered or removed by general blood-letting, the local inflammation often has to be combated by topical blood-letting, which now not only becomes more efficacious in reducing the determination to and distention of the inflamed part, but also contributes to keep down the general excitement. In fact, local blood-letting, by cupping or the application of numerous leeches, may be carried so far as to be tantamount in effect to general blood-letting; and the cases in which it exercises this power are of the same nature as those in which slow bleeding answers best. In either extremes of age, and in feeble subjects, local bleeding only is admissible. It is chiefly suitable too for inflammations which are superficial and extended, as those of the pleura or peritoneum. It is of much less avail in pneumonia, cerebritis, and other inflammations of deep-seated or parenchymatous organs.

Of late years blood-letting may be said to have very much gone out of fashion: so much so, indeed, that not a few practitioners of the present day openly declare that they never bleed, and very rarely apply leeches or cupping. And although the reported experience of these enemies to the lancet does not speak conclusively in their favour, yet I am ready to admit that in my own practice, the occasions for venesection and local blood-letting are much more rare than they were twenty or thirty years ago. It may be true that the type of disease has undergone a change during that period, being now much less sthenic than formerly; but I suspect that the change in practice outdoes any such variations in disease, and like fashions in other things, tends to an unreasonable extreme. Our improved knowledge of the important nature and relations of the blood as an integral part of living structure, should teach us to be careful not to waste it wantonly: but in our anxiety to avoid bloodshed, we must not forget that unrestrained and prolonged inflammation is itself destructive to the blood as well as to the solids which it invades, and that a little blood judiciously and seasonably withdrawn by depletion, may save much blood from being spoilt and wasted by the unchecked progress of inflammatory disease.

505. Of the other antiphlogistic evacuants none are equal in power to purgatives, which are great aids to blood-letting, and

available in most cases of severe inflammation, uncomplicated with gastro-enteritic irritation. They operate on so large a surface, (1400 square inches according to Meckel), that they powerfully affect the system, and their effect may be even pushed to the extent of producing syncope; but such an extreme result is attended with much exhaustion; their too prolonged use may also cause intestinal inflammation. The chief benefit derivable from purgatives may be obtained by administering a few efficient doses at the commencement of the treatment. These then aid the depressing effect of blood-letting, remove fæculent matter, which is often a source of irritation, and clear the intestinal canal for the operation of other medicines. The stronger and less heating purgatives are to be preferred for this service, such as calomel, jalap, and salts and senna, combined with tartar-emetic or colchicum. The union of several, which have a tendency to operate on different parts of the canal, answers best. The saline aperients are partly absorbed into the blood and there exert catalytically a gentle antiphlogistic influence upon its constituents, at the same time that the evacuant result is gained. In plethoric subjects, especially if high-toned fever is present, it is sometimes difficult to get purgatives to act efficiently, on account of the tension of the vascular system, and the languor of the absorptive process. After a full bleeding they will, however, resume their power even under these circumstances. Or the same end may be gained by combining them with a full dose of tartar-emetic, for reasons that will be made apparent presently.

506. Of the various internal remedies for inflammation with fever, that which most nearly resembles blood-letting in its effects is tartarized antimony. It is however far less sure in its operation, and its influence is by no means proportioned to the quantity administered; yet under its use, especially if it follow blood-letting, the pulse commonly becomes less hard and frequent, the heat of skin is moderated, and perspiration ensues, the local symptoms being at the same time more or less improved. Sometimes it causes vomiting, more rarely purging; but its antiphlogistic operation is most satisfactorily attained when these effects do not ensue to interfere with the continued influence of the medicine; I have frequently found its utility most marked, when it did not cause even nausea or profuse diaphoresis. Tartarized antimony, and the milder preparation, James's powder, have been very long used in

this country as febrifuge medicines; and Dr. Marryatt, who practised at Bristol in the last century, prescribed large doses of the former in the treatment of inflammation. The practice was since carried to a greater extent by Rasori, and other Italian physicians, who gave from 10 to 120 grains in twenty-four hours. Laennec adopted the remedy, but used it in more moderate quantities, prescribing from one to four grains in some agreeable vehicle every second or third hour for six doses; and then intermitting or continuing it, according to circumstances. In pneumonia and rheumatism, he considered it the chief remedy. Most practitioners in this country now consider tartar emetic a valuable auxiliary in subduing inflammation, chiefly to be used after blood-letting; or in slighter forms of the affection, where blood-letting is inexpedient. I rarely find any gain in raising the dose beyond two grains every three hours; and in most cases one grain, half a grain, or even less, fully answers the purpose. The first doses sometimes cause vomiting; but this unpleasant action generally subsides as the doses are repeated, and it may be prevented even from the first by giving the medicine in an effervescing saline draught, with from four to eight minims of the diluted hydrocyanic acid in it. Antimony acts most satisfactorily in inflammations of vascular parenchymata and complex structures; such for instance as are involved when the lungs and air passages, the testicles, the mammæ, the skin, and the joints considered as a whole, are the seats of the affection. It is less effectual in inflammations of serous membranes, and altogether unsafe in inflammatory disorders of the intestinal canal. It is most beneficial in the early stages of the mischief, especially when attended with fever; but seems to have little effect on the products of inflammation.

The manner in which antimony operates in reducing fever and inflammation is yet debateable ground. Rasori considered it to be a direct sedative or *contro-stimulant*, diminishing the excitability of the vascular system, and so neutralizing inflammation. He supposed the *tolerance* or power of the body to bear large doses of the remedy, entirely to depend on the presence of inflammation in the system; but, as Laennec has observed, this is not correct; for although patients suffering from inflammation are less easily nauseated than others, yet after the disorder has been subdued, they have often continued to take 12 or 18 grains daily without nausea, or even loss of appetite. Laennec at first considered that

the medicine acts as a revulsive, through irritating the stomach; but this view having been made by the Broussaians a ground for opposing the use of the remedy, he latterly attributed to it a sorbefacient operation. It seems to me, that the most reasonable notion is, that it chiefly acts by diminishing the tonicity of the vascular system; and that in addition to this it possesses a catalytic power over the blood-constituents, reducing their plasticity and richness, and so rendering them less able to keep up adhesive stagnation. There can be no doubt that the immediate influence of a nauseating dose of tartar emetic is upon the vagus nerve and its allies. Through this influence it produces sickness, depression of the heart's action, muscular relaxation, and retarded breathing. No nausea is produced until a portion of the medicine has been absorbed into the blood and carried by it to the nerves. It then operates simultaneously upon the nerves of the stomach, the heart and the respiratory apparatus. Hence the primary power of antimony is purely sedative, and on this account it cannot fail to prove a most valuable agent wherever high-toned fever is present. So soon as the force of the heart is diminished all pressure upon the capillaries is relieved; and so congestions, determinations, and stagnations have an opportunity afforded them to right themselves—so also the consequent fever begins to decline. This is why antimonial treatment possesses so high a reputation in the management of such sthenic cases as naturally possess a very rapid progress, as for instance croup and certain forms of pneumonia. Its operation upon the heart and respiratory muscles is no less sudden and powerful than that of these very formidable disorders. The catalytic action on the blood is of necessity a much slower and less available one, than that upon the organic nerves, but when administered in doses that are much too small to possess any nauseant power, it gradually impoverishes the nutrient liquid. It is probable that when thus employed in small doses, it is entirely eliminated from the circulation through the mucous membranes and the skin. In this way it acts as a gentle evacuant and derivative. It is hence in constant use as an expectorant and diaphoretic in various febrile and inflammatory disorders (§ 122). Small doses certainly relax the pulse and skin, and, where there is no fever, produce perspiration without stimulating. They also seem to increase the biliary and intestinal secretion. In inflammation and fever, larger doses are required to produce

the same result, because then the sedative influence must first come into play to reduce the force à tergo, before the catalytic and eliminant influence can be secured. In this way the deranged circulation is equalized and quicted, the determination to, and distention of, the inflamed part are diminished, and the vessels generally are placed in a condition favourable to the performance of their natural offices of secretion, which extreme tension had before interrupted. It is quite possible too that deoxidizing power, such as has been before alluded to (§ 494) may have some connection with the result, and this would in some degree account for the greater tolerance of the medicine in inflammatory disease, which involves a process of hyperoxidation. This suggestion is however at present only based on hypothesis, and might with advantage be tested by experiments on the lower animals.

507. Another great remedy in inflammation is mercury, given alone or combined with opium. The combination of calomel and opium was first employed by Dr. Hamilton of Lynn Regis; and the rules which he laid down for its use have hardly been since improved on. After a sufficient venesection and a full purge, he administered from one to five grains of calomel with from one-fourth of a grain to one grain of opium every six, eight, or twelve hours. When much fever was present with dryness of skin, he added a little tartar emetic and camphor. If no relief ensued in twenty-four hours, venesection was repeated. Most practitioners admit the power of this remedy, although some ascribe its efficacy to the mercury, others to the opium: and the proportions in which these medicines are united have accordingly been varied considerably. The beneficial effects of this remedy depend generally, but not entirely, on the mercury affecting the system, as is manifested in adults by fœtor of the breath, and tenderness and swelling of the gums; and in children, by spinach-like evacuations from the bowels. Amendment is, however, often evident before these results take place. They are merely the signs of the full saturation of the blood by the medicinal agent. Its presence in a much slighter degree is commonly curative. In iritis, the influence of mercury is made *visible* by the removal of the effused lymph; so that it obviously in some way promotes absorption, as well as prevents effusion. The same "sorbefacient" operation is seen in the effect of mercury in removing the callous margins of indolent syphilitic ulcers, and in its promoting the spread of phagedenic

ulcers. Dr. Farre thinks that mercury destroys the red corpuscles of the blood, and causes in the system a disposition to erythematic inflammation, which is incompatible with the phlegmonous or plastic phase of the disorder; but this view is opposed by the fact that lymph is thrown out, and that granulations form and healthy ulcers heal during mercurial action. A brief review of the modus operandi of a combination of mercury and opium may be advantageously taken here, for although there is no certainty that the matter is fully and satisfactorily understood, a statement of what is best known of the effects of these medicines, may prove a valuable guide in their administration and management.

The opium is useful in preventing the mercury from purging, and in subduing the nervous irritation attendant upon inflammation, which is as we have seen one cause of that sympathetic excitement which, when complete, constitutes fever (§ 410). This salutary effect of opium is sometimes gained when it is administered alone after the vascular excitement has been subdued by a large bloodletting, as well as in cases in which nervous irritation forms a prominent element of the disease: here a full dose of opium subdues the remains of the inflammation better than any other antiphlogistic remedy; it seems to paralyze those sympathies which are concerned in renewing or maintaining the excitement of the inflammatory fever. So, too, when combined with mercury, the opium exercises the same narcotic influence; whilst the mercury obviates the opiate's astringent effect on the secreting organs (§ 66, 173). The mercury also augments the biliary and intestinal secretions; sometimes inducing copious mucous and bilious evacuations, as antimony is eliminated from the blood mainly by the skin and pulmonary mucous membranes, increasing their secernent activities in the process. Mercury is chiefly thrown out through the cells and vessels of the liver and the intestinal mucous membranes, augmenting their functions in a similar way. M. Lehmann has detected the mercury in the alvine excretions of persons who have had it in their blood, and M. Buckheim found it in the bile of dogs, to whom he had given it. From the result which is obvious to direct observation in iritis, it is clear that mercury has the power to facilitate the solution and removal of the effused lymph. How it effects this is yet uncertain; but probably by catalytically calling up changes in the condition of the blood, through which

the quantity of the fibrin and white corpuscles,—the constituents whose presence is mainly concerned in inflammatory processes,—is diminished. Mercury certainly is chiefly useful where the blood is very much buffed, and where there is a tendency to copious fibrinous effusions, as in inflammations of serous membranes and croup. Calomel and opium have little influence over high inflammatory fever; the system thus excited generally resists the mercurial action, probably on account of absorption being then arrested, or very imperfectly performed. The remedy then has no further sedative effects than such as proceed from its immediate action on the intestinal canal; and excepting so far as it is required for this sedative purpose, the combination is not well adapted for the earliest stage and most active forms of inflammation. In these circumstances the preliminary of blood-letting is requisite, and then the mercury is best united with antimony: if fever returns during the action of mercury, blood-letting or active purging may be again necessary for its reduction. In fact the combination of calomel and opium is less antiphlogistic, and more alterative in its operation than blood-letting, or antimony: it is inferior to them in the power to reduce inflammatory fever and active inflammation; but it is superior to them in arresting and removing the more plastic products of the process. Besides the comparatively slow influence exerted by mercurial preparations generally, there are however others which are peculiar to calomel, and which render it a most effectual remedy even in active inflammations; when given in large doses (from 5 gr. to ℈j.) it acts as a powerful cholagogue, and often causes the evacuation of dark green matter, which the examinations of Dr. G. Bird have shown to resemble the colouring matter of the blood, rather than bile, in composition. The operation of calomel employed in this way does in truth resemble that of blood-letting, being much more actively antiphlogistic than when it is used in small doses. This mode of exhibiting it has been extensively adopted in India, and has also been taken up in this country with much success by Dr. Chambers. The chief evil attaching to it, is its tendency to induce inflammation of the large intestines and dysenteric straining; on this account the plan cannot often be long persisted in.

508. Various saline medicines, such as nitrate of potass, and the alkalies combined with vegetable acids, deserve mention as serviceable auxiliaries in the treatment of inflammatory fever, although

they are comparatively inefficient when employed alone. Their dilute solutions allay thirst, and seem to cool the fever; hence they have obtained the title of refrigerants. It is uncertain how far they may operate by diminishing the cohesion of the corpuscles and the excess of fibrin in the blood (§ 438). It is highly probable that they do possess the power of rendering the fibrin less adhesive and plastic, and Mr. Gulliver states that he has been able to detect their influence in preventing the adhesion of corpuscles in inflammatory blood. But some of their good effect may certainly be traced to their augmenting the secretions, particularly the renal (§ 256), as they are eliminated from the circulation. They are all more or less diuretic; and most of them also supply an alkaline base, which unites with the lithic and lactic acids formed in the blood, and so facilitates the separation of these matters by the kidneys. Colchicum and digitalis are sometimes reckoned among antiphlogistic remedies; but in common inflammation they are of very inferior power. In the absence of high toned fever colchicum exerts a special action on the secretion of the liver, somewhat resembling that of mercury, and also augments the elimination by the kidneys (§ 257): digitalis too, operates as a diuretic, and as well as a sedative on the irritability of the heart: but during severe inflammation these effects are scarcely attainable by doses which it is prudent to administer. The same remark is applicable to hydrocyanic acid and various preparations of aconite. There can be no question that both of these agents are capable of depressing the action of the heart, and thereby of reducing the force of the circulation; but it would require large and dangerous doses to produce this effect during the excitement of active inflammation.

509. The utility of counter-irritants as a remedy for several of the elements of local inflammation has been already noticed (§ 493, 496); but their operation is positively injurious in sthenic inflammation during the prevalence of fever. They then add to the excitement of the system; and in proportion to the local inflammation which they excite, they prove a fresh source of inflammatory changes in the blood (§ 438). But after the fever has subsided under the influence of remedies, or has been exhausted by time, the advantage of counter-irritants predominates. The seat of their application ought, however, to be somewhat determined by the excitability of the vascular system: where this is great, the counter-

irritation should be more remote from the seat of inflammation; where it is comparatively slight, blisters may be applied in close vicinity to the affected part. Blisters and suppurating counter-irritants, which cause copious discharge, are the most useful remedies of the class: they tend to exhaust the lingering remains of inflammation, and to promote the removal of matters that have been effused during the active stage of the process. Such measures become our chief reliance when inflammation inclines to a chronic state, or when it has left such structural changes as cannot be speedily set right.

510. The *antiphlogistic regimen* comprises the avoidance of all circumstances and agencies that are capable of exciting or fatiguing the body or mind of the patient. Absolute rest in bed in a very quiet, rather dark, yet cool and carefully ventilated apartment, greatly favours the restoration of tranquillity to the circulation. The exclusion of noise, bustle, and other sources of excitement, and the careful removal of all irritating excrementitious matters, are essential conditions to its observance.

The *antiphlogistic diet* comprehends a similar avoidance of all irritating, and stimulating, as well as the more nourishing, articles of food. The proteinaceous materials, meat, eggs, and in severe cases, even bread and milk must be prohibited, besides all oily nutriment, which tends to increase the heat of the body: amylaceous, gummy, and saccharine matters may be taken sparingly, and are best given in thin fluids, such as barley-water, tea, weak gruel, and arrow-root. The thirst that is generally present, suggests the free use of diluents, which are serviceable in cooling the body, and in promoting the action of diuretic, diaphoretic, and other evacuant medicines; but even these bland fluids, if used to excess, tend to oppress the stomach and disturb the heart's action; and may also prove hurtful by augmenting the bulk of the circulating fluid. When fever is present, the total loss of appetite is a sufficient indication of the necessity for abstinence from food; the stomach commonly will not retain, or if it does, will not digest, any but the weakest kinds of nutriment; but this is not the case in every attack of inflammation, although self-denial and restraint may on that account be only so much the more imperatively demanded.

511. *Exhaustion.—Depression from poison.* (See Table, 16 and

17.) The exhaustion which is consequent upon the long-sustained excitement of inflammation and fever, often renders stimulants and tonics, as well as a generous diet, necessary in the after treatment; but the greatest circumspection must be exercised in making sure that these agents are employed in proportion to the wants of the case, and that they are not used so early or pushed so far as to rekindle the inflammation afresh, or to produce other disorder in the weakened organization. No diffusible stimulant is more generally or safely applicable at this juncture than ammonia, which may be most conveniently exhibited by adding its carbonate to the saline draught. It seems possible that its utility may in part depend on its supplying the azote necessary for the conversion of amylaceous and saccharine nutriment into albuminous or gelatinous principles, as Dr. Alison has conjectured. Alcohol and ether obviously act by furnishing a material that can be employed in the production of animal heat, so that the oxygen in the blood is prevented from preying too much on the textures. Similar aids are also required, to support the system against the pernicious influence of purulent or gangrenous matter, that results from the inflammatory process. Even in cases of simple suppuration, the occurrence of the premonitory rigors, and the diminished strength of pulse and heat of skin, point out the time when the reducing plan is best exchanged for one more supporting; but the extent to which this change is made should depend on the character of the symptoms, and on the efficiency with which nature is attempting the process of limiting the mischief to the destroyed part. When suppuration has once commenced, there is no probability of its retrogression; and therefore the obvious indication is to promote its completion and to prevent as far as practicable its extension, and the diffusion of the pus through adjoining parts and through the system. This object is best secured by the use of local stimulants, especially heat combined with moisture. Such applications promote determination of blood to the part, whereby the formation of pus globules is quickened, as is also the solution and absorption of the compressed fibrin and tissues (§ 461), whilst surrounding vessels, inflamed but less obstructed, are engaged in throwing out a barrier of lymph, which retains its vitality and resists the solvent action and advance of the pus in all directions, except that in which the textures yield most, and through which it is ultimately to find vent. The local treatment of gangrene also comprises more or less the use of

stimulant applications to aid the process of separation, or sloughing, of the dead from the living parts. It is probable that in all cases, some purulent or gangrenous matter finds its way into the circulation; therefore, in addition to stimulants and tonics, antiseptics (such as chlorinated liquids, nitro-muriatic acid, chlorate of potass, chloroform, and creasote) are sometimes with advantage given internally to counteract the septic influence on the blood; but above all things the secretions are on this same account to be kept free, to promote the elimination of the morbid matter (§ 260, 443), the foul nature of which is commonly evinced by the fœtor and disordered appearance of the fæces and urine. For a similar reason, foul suppurating and gangrenous sores require to be dressed frequently, and their discharge corrected and promoted by antiseptic and alterative applications. No application to gangrenous or sloughy sores is more efficacious than recently prepared charcoal. Its power to correct putridity and fœtor has been long known: but Dr. Stenhouse has shown that it does more than this for parts in a state of gangrene. It not only absorbs and decomposes all putrid effluvia and discharge, but its contact hastens the decomposition and removal of the dead tissue; it is therefore most beneficial in promoting the removal of sloughs. I lately had a patient with extensive sloughs on the legs, consequent on dropsy: the fœtor was overpowering, and the system seemed to be rapidly sinking under the deadly influence of the mortification; when after the parts were freely sprinkled with charcoal powder, the whole evil seemed immediately checked: the fœtor ceased, the constitutional depression diminished; the sloughs gradually diminished and separated; and the wounds granulated and healed in the course of a few weeks. I have also found much advantage from the use of enemata of fine charcoal powder with water and a little laudanum, in severe cases of dysentery and diarrhœa with very offensive discharges, when there was reason to suspect the large bowel to be in a sloughy state.

18. *Removal of the products of Inflammation.*

512. The serum, liquor sanguinis, and healthier kind of fibrin and exudation corpuscles (§ 424), are removed after they have been effused from the vessels by the natural process of absorption (that is, osmosis into the adjoining vessels, the fibrin having been previously made soluble by conversion into tritoxide of protein, or commuted

into fluid fat), aided by the influence of such remedies as have been already mentioned, particularly mercury, iodine, iodide of potassium, colchicum and other diuretics, and the application of blisters and other counter-irritants. As in all probability a free circulation of blood favours the removal of effused solids partly by further oxygenating them, the idea has been suggested that the process may be quickened by the internal exhibition of agents which contain a large proportion of oxygen in loose combination. Nitric acid answers to this description; and whether this be one of the ways in which it acts or not, I can affirm, from much experience in its use, that it is certainly the best medicine I know for hastening the state of convalescence from inflammation. In doses of 20 to 30 minims three or four times daily, administered in some aromatic or mild bitter vehicle, it often cleanses the tongue and improves the appetite, circulation, and strength. Its utility is somewhat limited by its tendency to irritate the bowels. But this result very rarely occurs. The products of inflammatory effusion in external parts are sometimes more speedily dispersed by the agency of what are called discutients; these are generally slightly stimulant applications, such as warm spirit lotions, or solutions of hydrochlorate of ammonia, common salt, or iodide of potassium; and in more chronic cases, liniments containing mercury, iodine, ammonia, and spirit, used with friction. They operate much in the same way as the various other remedial influences already alluded to, as for instance by promoting a free current of blood through the part without producing distension, and so facilitating absorption; by diminishing the atonic congestion left by inflammation; by increasing secretion or exhalation; and by compressing the structures. The restoration of a vigorous state of the circulation and excreting function is often necessary to effect the removal of copious effusions and deposits consequent upon inflammation. Thus I have often observed that pleuritic effusions show no signs of dispersion until the strength of the body begins to return under restorative treatment. From the researches of Mr. Gulliver and others it appears that the longer an inflammatory product remains without becoming organised, the more does it abound in particles or granules of a fatty character, consisting of margarin and olein. This change, which is like that which forms atheromatous matter in arteries, and aplastic tubercle elsewhere, probably depends on a spontaneous conversion analogous to the

production of adipocire from flesh kept moist and secluded from the action of the air. To prevent such a result, and perhaps to arrest it when once begun, or even to remove the solid deposits which have been laid down, we naturally look to measures that increase the free circulation of arterial blood in and around the part; which, either by the agency of the oxygen or of other solvent principles which the blood contains, may possibly disperse and carry away the fats, and other solid deposits. Probably in this way the cod liver oil operates in the removal of the products of inflammation: being peculiarly fluid and diffusive it penetrates the tissues and dissolves the more solid fatty matters, into which the products of inflammation degenerate. This subject will be again under notice when speaking of *Degenerations and Morbid Deposits.*

TREATMENT OF VARIETIES OF INFLAMMATION.

513. The *sthenic* (§ 477) form of inflammation requires the whole array of antiphlogistic remedies to be directed with energy against it. The prevalence of determination, active vascular excitement, and the over-fibrinous condition of the blood, demands the free use of blood-letting, calomel, purgatives, and antimony, at the onset; and the full operation of mercury if the disease continue. In *asthenic* inflammation, on the other hand, blood-letting is ill borne, and can only be practised locally, if at all; the chief reliance must therefore then be placed upon antimony or mercury, and blisters, which, in the absence of high fever, may be employed at even an early period. The diet, although light, should not be too spare, and may include such nutriment as animal broths, milk, farinaceous food, and sometimes fish or white meats. Mild stimulants, particularly ammonia, may sometimes be required, in order to enable the system to complete the processes of protection and elimination which are always needed during inflammation (§ 443, 4).

514. *Acute* inflammation (§ 478) demands a very prompt use of antiphlogistic remedies; but the choice of the particular kinds and the extent to which their action is to be pushed, depends on whether the inflammation be sthenic or not. *Subacute* inflammation is generally of the asthenic form; and being less severe, as well as slower in its progress and effects, it does not require such active treatment as that of higher tone. It must not, however, be neglected; for its obscurity sometimes renders it dangerous:

and it not uncommonly does serious injury to both function and structure in the most insidious way. Its habit of long continuance and its liability to recur, render it necessary to continue some degree of antiphlogistic treatment for several weeks. When it has lasted thus long, it tends to become more asthenic, and the lowering antiphlogistic remedies are no longer serviceable; sometimes it is then proper even to call in the aid of tonics and improved diet, whilst the local mischief is attacked by counter-irritants. Mercury with opium is generally one of the most useful remedies in subacute inflammation.

515. *Chronic* inflammation recedes still further from the inflammatory type, and borders more on congestion or disease of nutrition. The absence of fever usually supersedes the necessity for employing the stronger antiphlogistic remedies—and those suited for local inflammation are sufficient; general blood-letting is needful only when plethora also is present; and even local blood-letting should not be too freely employed, for it tends to weaken a system which is already too feeble. Counter-irritants are constantly useful; and their application should be varied according to the seat and extent of the inflammation. In affections of serous membranes, a succession of large blisters answers best. For chronic inflammations of parenchymatous organs, and ulcerations of mucous membranes, suppurative counter-irritants, and setons, are of more avail. Mercury and the other alterative medicines, especially salines and the iodide of potassium, are often useful. Mercury answers best in the more sthenic cases where there is effusion of lymph, leading to tough thickening and induration of textures. Iodide of potassium is better adapted for chronic inflammation of an asthenic character, where there is reduced blood and strength, with tendency to ulceration, suppuration, or aplastic deposits. It is often requisite to keep up the general strength by mild tonics, such as sarsaparilla and the light bitters, and to allow a nourishing, but not stimulating diet, regulated according to the digestive powers of the patient. Careful attention to the state of the excretions is particularly necessary. Courses of mineral waters, and change of air by gentle travelling, are also often serviceable in chronic inflammations.

516. In *congestive* inflammation (§ 480), the treatment for congestion should be combined with that for subacute inflammation. If the subject be plethoric, general blood-letting is advisable;

otherwise local bleeding and various derivants or revulsives, among which cupping and dry cupping, or hæmostatic ligatures (§ 318, 503) are the most effectual. Rubefacient applications, such as large mustard poultices, and strong ammoniacal or mineral acid liniments, applied over a large surface, are of considerable efficacy; and their use can be repeated daily and varied in diverse ways for a long time. Mercury and antimony are both of considerable value in the more active stage of congestive inflammations: the former especially for inflammations of the abdomen, the latter for those of the lungs. In the absence of much irritation, iodide of potassium, mineral acids, and even quinine, may avail in obviating the congestive condition. So, too, when secreting structures, like the liver, kidneys, and mucous membranes, are principally concerned, stimulants which excite their various secretions will do the same thing. In congestive inflammation, as in long continued congestion, the blood suffers from stagnation in the affected part, and being spoilt (§ 191) is very apt to prove a cause of contamination to the rest of the circulating fluid in the body. Hence the propriety of using the various depurative remedies which increase the excretions, &c., and of resorting to iron, quinine, and nourishing food during the convalescence. Further particulars, that have relation to this subject, will be found where the treatment of congestion is considered (§ 313, *et seq.*).

517. The appropriate treatment for *phlegmonous* inflammation* is generally such as is suited to the sthenic form. *Erysipelatous* inflammation being as commonly asthenic, is not benefited by active antiphlogistic measures; and in some cases it is necessary even to adopt quite an opposite treatment, and to give ammonia, wine, bark, &c.: this is when the influence of the specific poison (§ 482) predominates. In other cases, the reaction against this influence is very vigorous, and requires to be held in check. Generally the administration of a saline, combined perhaps with small doses of tartar emetic, keeping the secretions free, and applying warm fomentations to the affected part, answer best at first; and these measures must in a few days be replaced by giving chloric ether, ammonia, wine, and bark or quinine, with improving

* This term is used here in the sense in which Cullen employed it, as opposed to erythematic or erysipelatous. I mention this, because boils, or furuncular inflammations, are commonly of an asthenic character, and not unfrequently require that measures should be adopted to support the system.

nourishment.* A more direct counter-agent to the poison in the blood, is a desideratum; but scrupulous cleanliness and careful regulation of temperature and ventilation, with a free use of chlorides or charcoal in the room, to a great extent prevent the disease from spreading in hospitals and sick chambers where there are effluvia from sores or wounds. Punctures and incisions, which relieve the inflamed part by causing a discharge of blood and serum; cauterisation by nitric acid or nitrate of silver, which arrests the progress of the disorder by exciting a different kind of inflammation—and the application of mercurial ointment, which seems to modify its character,—constitute the chief kinds of local treatment that have been found useful for erysipelas.

518. *Pellicular* or *diphtheritic* inflammation is usually of an asthenic character, and is little benefited by blood-letting, but may be counteracted by mercury, the grand remedy for all inflammations effusing lymph; and by local astringents, or even caustics, which powerfully excite the vessels, and so change their action. Thus the direct application of nitrate of silver, in substance and in solution, of hydrochloric and diluted nitric acids, (one part to three or four parts of honey used with a brush,) and of finely powdered alum, has been used with advantage in diphtheritic sore throat. In the croupy inflammations of children, the most effectual remedies are, calomel freely given, antimony, and certain expectorant or attenuant medicines, which promote the more liquid secretions of the affected membrane. The aphthous inflammation of children is readily subdued by the application of a saturated solution of borax, or of a weak solution of sulphate of zinc, employing at the same time magnesia and mild mercurial aperients to correct the secretions of the alimentary canal. A weak solution of tannic acid is also often serviceable in removing erythematic inflammations of the mouth and fauces.

* Erysipelas of the head and scalp is the form of the disorder which falls most commonly under the observation of the physician; and although it is often attended with formidable symptoms, I have very rarely known it to prove fatal. All the cases (twenty in number) which have been under my care at the hospital, recovered in a period varying from one to four weeks, under the general treatment recommended above, without any other local measures having been adopted than the use of fomentations, where the patient likes them, very rarely a leech or two to the temples, and poultices to any succeeding boils. In private practice stimulants and tonics seem to be necessary at an earlier period and to a greater amount than in hospitals; and I do not remember to have seen a case of erysipelas, uncomplicated with organic disease, prove fatal when this mode of treatment was unremittingly pursued.

519. *Hæmorrhagic* inflammations (§ 484) are often of the congestive kind; and the hæmorrhage arises from the excessive distension of vessels, as instanced in the hæmatemesis that sometimes precedes gastritis, the bloody discharges of dysentery, and the hæmaturia which occasionally ushers in inflammation of the pelvis and tubes of the kidney (pyelitis). I have often remarked that the hæmorrhagic tendency exhibited in purpura, and sometimes combined with inflammation in lichen lividus, and ecchymosed erysipelas, is connected with congestion and torpid action of the liver (§ 171), and that it is accordingly corrected by mercurial and saline aperients, followed by nitric or nitromuriatic acid.

520. *Scrofulous inflammation* (§ 485) being generally asthenic, is little benefited by blood-letting or other active antiphlogistic measures. Its disposition to produce at once cacoplastic and aplastic effusions makes it important that it should be subdued, if possible, at an early stage, whenever it occurs in situations in which the formation of curdy pus or tuberculous matter would be injurious. In scrofulous inflammation of the lymphatic glands, warmth, with moisture and discutient applications, (solutions of muriate of ammonia, of iodide of potassium, and warm vinegar,) often succeed in dispersing the swelling before it comes to suppuration. In the internal inflammations of scrofulous subjects, such as of the lungs, glands, and joints, local depletion is generally advisable, followed by free counter-irritation of a character that will cause an external discharge of pus. Dr. O'Beirne and others recommend a full mercurial course for scrofulous inflammation; but this I consider admissible only in the earliest stage of the disease, and in its most active forms; for I have found (and I believe it is consonant with the experience of most practitioners) that mercurialization greatly injures the constitution of scrofulous subjects, tends in them to degrade the products of inflammation, and promotes softening and ulceration in textures where deposit has already taken place. It seems to me, that it is rather asthenic or chronic inflammation (§ 479), occurring in subjects who are not scrofulous, that is benefited by mercury, than that which is peculiar to the scrofulous diathesis. Preparations of iodine, especially the iodide of potassium, are more suited for combating low scrofulous inflammation; their operation is commonly salutary, when the constitution has in it the taint of scrofula.

The main source of the peculiarities of scrofulous inflammation,

and therefore the chief consideration to be kept in view in determining the peculiar treatment, is the diathesis or constitutional fault; this seems to consist in a degraded condition of the plasma, or nutritive material of the blood (§ 211), often connected with a deficiency of red corpuscles (§ 185); an invigorating and nourishing treatment and regimen are therefore especially indicated (§ 218, 219), and may sometimes be beneficially adopted even when low inflammation is present; this being at the same time attacked by counter-irritation or other local antiphlogistic measures. Therefore the best remedies in scrofula are tonics, nourishing diet, and such other means as are calculated to improve the nutritive function and general health. Even the medicine that has attained the highest repute in its treatment, may be considered in the light of a nutriment. I allude to the cod liver oil, which has long been employed on the Continent, and in a few places in this country, but only within the last ten years has been received into general use. Its extensive adoption depended much on the improved method of preparing it discovered by British chemists, and which procures it fresh from the livers of the fish without taint or nauseous odour. Having ascertained that the oil thus pure and tasteless, was at least as efficacious as the nauseous brown stuff previously tried, I recommended it strongly to the profession, and it is now very extensively used. Commencing with the dose of a teaspoonful twice or thrice daily (immediately after each meal), and gradually increasing this to a tablespoonful, this medicine produces an astonishing improvement in most scrofulous patients. It seems to give a new impulse to nutrition; for an amendment is soon perceived in the accession of flesh, in the freshening of the complexion, and in the augmentation of the strength; commonly the pulse is moderated, the appetite increased, and more or less amelioration is manifested in the local inflammation. Thus scrofulous swellings diminish and even disperse under its influence; enlargements of joints are reduced; ichorous sores are caused to secrete a more laudable pus; the profuse discharge from abscesses and vomicæ is lessened; and consequently hectic fever, and night sweats and its other concomitants are checked. The chief practical difficulty that has to be encountered in its employment, is its tendency to disorder the stomach and liver: the latter I sometimes find to become remarkably enlarged during its exhibition. The utility of cod liver oil in tuberculous disease, and its mode of action,

will be considered under the head of cacoplastic and aplastic deposits. The other medicinal agents that have been found to possess the most corrective power over the scrofulous diathesis, are the iodides of potassium and iron, chalybeates generally, bitters with alkalies, bark, or quinine, and mineral acids. Equally important in its treatment are residence in pure and mild air, especially near the sea or on mountains; warm clothing; regular exercise, friction upon the skin, and the adoption of other measures that promote the superficial circulation; warm sea bathing, or cold (when the patient can bear the shock and chill) (§ 79), followed by friction; a good proportion of wholesome animal food, and a careful regulation of the state of the excretions. All these are of great efficacy where there is a tendency to this form of disorder, and they are often useful even after inflammation has produced structural disease; for they may then do much to prevent its increase, and to assist nature in removing or rendering inert, the cacoplastic, or aplastic matter that has been deposited.

521. The peculiarity in the treatment required for *rheumatic* and *gouty* inflammation, consists chiefly in the need for the elimination from the system, of the morbid matter which is the cause of the derangement (§ 251—254). The remedies which are best adapted to promote this object have been already mentioned (§ 252, 254). But it must be remembered, that the inflammation and fever present in rheumatism or gout may be so high and sthenic, as to require active antiphlogistic measures before colchicum or mercury can be made to act; this is particularly the case in acute rheumatism, in which inflammation is excited in many parts at once; and in which probably as a consequence (§ 438), the blood becomes surcharged with fibrin. Here general blood-letting is useful, not in order to remove the cause of the inflammation, but to arrest the inflammation itself. If after blood-letting, the material cause of the rheumatism is still abundant in the blood, which is commonly the case, it is then advisable to give colchicum with alkalies, iodide of potassium, or nitre in large quantities and much diluted, (Gendrin,) or lemon juice, (Owen Rees,) or bicarbonate of potass, (Garrod,*) and to continue the employment of the remedy

* Med. Chir. Trans., 1855. Dr. Garrod relies entirely on the use of the bicarbonate of potass given in such quantities (℥ss or ℈ij in ℥iss water every hour or two hours) as to induce an alkaline state of the urine. In my hospital practice in rheumatism I made several comparative trials of carbonated alkalies, alone, and conjoined with colchicum;

for some time, until the morbid matter shall have been sufficiently eliminated. In asthenic cases, the use of bark, quinine, and other tonics, often proves serviceable in improving the tone of the vessels after the irritation and exhaustion which the disease and its treatment have produced (§ 174).

The infectious character of *gonorrhœa* and *syphilis* proves the specific nature of their cause; but it is only with regard to the latter that we can speak of a specific remedy. How mercury cures syphilis is quite uncertain. It is not by any property directly destructive to the virus; for the disease cannot be prevented from appearing by mercurial action; and when present, it is not always cured by it. It is more probable that mercury acts as an alterative, by removing the callous indurations of syphilitic sores and swellings, and by increasing the secretions, and thus gradually eliminating the syphilitic virus from the system. It is now well ascertained that other remedies which promote absorption and secretion, also favour the cure of syphilis, especially the iodide of potassium. Gonorrhœal inflammation generally tends to a spontaneous cure in a few weeks' time, but this may be accelerated by adopting mild antiphlogistic and demulcent measures at first, and by using astringent injections and terebinthinate medicines subsequently.

and the result was decidedly in favour of the latter combination; but I never pushed the alkaline treatment so far as Dr. Garrod advises. Under treatment with bicarbonate of potass, Dr. G. found the convalescence established in from four to ten days. Under treatment chiefly with alkaline carbonates and colchicum, the same result was attained in five or six days. The success of the two methods seems therefore to be nearly the same; but I must acknowledge that colchicum is more apt to disagree than the large doses of bicarbonate of potass appear to do. I should expect that the latter must considerably impoverish the blood, and that a course of chalybeate medicine, as sometimes employed by Dr. Garrod, would be generally proper after convalescence.

CHAPTER IV.

STRUCTURAL DISEASES, OR DISEASES OF NUTRITION. ULTIMATE AND PROXIMATE ELEMENTS.

SECTION I.

NATURE AND CLASSIFICATION.

522. ALTHOUGH we have had frequent occasion to advert to the changes in the process of *textural nutrition* effected by inflammation, congestion, &c., and although nutrition might be included with propriety under the head of *secretion* (§ 178), a primary element, it has yet been deemed better to defer all notice of the diseases of nutrition until now; both because the preliminary consideration of disorders of the blood and of its vessels serves really as the best introduction to the subject, and because also structural disease cannot be resolved into ultimate and proximate constituents. Analogy, indeed, might seem to indicate that ultimate structural disease is that which affects elementary structures singly, such as muscular fibre, nervous matter, cellular texture, &c.; but structural disorder is rarely found to be practically thus confined to one anatomical element: it rather involves all the textures that are intimately associated together in the affected organ or part.

Full details of the nature and variety of structural disease belong rather to the department of morbid anatomy than to the scope of this work. It will be sufficient if here the chief forms are alluded to while tracing the alterations in the function of nutrition which produce them. This method will enable us to class these diseases in an arrangement corresponding with that which was adopted with regard to the elements of functional disease (§ 104), and will afford a facility for making a brief statement, under each head, of whatever is known regarding their nature and origin, and the remedies which influence them.

As in the case of functional diseases, so of structural lesions, which are modifications of ordinary textural nutrition, they may be comprehended under the three heads, *increased*, *diminished*, and *perverted* nutrition.*

ELEMENTS OF STRUCTURAL DISEASE.

- DISEASED NUTRITION
  - Increased = hypertrophy.
  - Diminished = atrophy.
  - Perverted
    - Induration.
    - Softening.
    - Transformation and degeneration.
    - Deposits
      - Euplastic
        - Cicatrices.
        - False membranes.
      - Cacoplastic
        - Cirrhosis.
        - Fibro-cartilage.
        - Grey tubercle.
        - Atheroma, &c.
      - Aplastic
        - Yellow tubercle.
        - Calcareous matter.
        - &c.
    - Morbid growths
      - Non-malignant
        - Cysts.
        - Tumours.
        - Hydatids, &c.
      - Malignant.
        - Carcinoma.
        - Encephaloma.
        - Melanosis.
- ALTERED MECHANISM
  - Contraction
  - Dilatation
  - Obstruction
  - Compression
  - Displacement
  - Rupture, &c.

The above classification is convenient on account of its simplicity, but it must be borne in mind that it is too precise to be *rigidly* applicable in the generality of cases. Different kinds of lesion of nutrition often graduate into each other, and are very

* Although considerable advances have been made in pathological anatomy, and although several new works upon the subject have appeared since the publication of the first edition of this treatise in 1843, it is satisfactory to me to find that the progress of knowledge has not in any material point superseded the views that were there given of the elements of structural disease, but that in many instances these views have been signally confirmed and extended. Under these circumstances, I have had to add to, rather than to modify the text; and in preference to new classifications and uncouth nomenclature, which it has been attempted to introduce from various foreign writers, I have retained my former division of the elements of structural disease, designated by terms which are in common use among British pathologists. For further valuable information on details of morbid anatomy, however, I refer the reader to the works of Rokitanski, Vogel, and Lebert; especially those of the two first authors, which have been ably translated and edited in English by Drs. Day, Swayne, Sieveking, and Mr. Moore:

commonly combined together: hypertrophy of some textures coexists with atrophy of others; perverted nutrition is mixed up with excessive or defective nutrition; or several of these different changes occur in succession. We have already found this to be the case with the results of inflammation (§ 479); and inasmuch as that process exaggerates and disorders the changes of nutrition, it has furnished us with many examples of the production of structural lesion. But the alterations that are now to come under consideration are such as take place altogether independently of distinct inflammation, and such as are mere modifications of the ordinary operations of nutrition or reparation, continually going on in the textures of the living body.*

523. Continued nutrition of the organized textures is required for two reasons:—1st, In order that their growth and development may be perfected. 2ndly, In order that the waste entailed by their vital activities may be repaired. But viewed in this light, the blood may be said to require nutrition as much as any of the solid structures of the frame. Its pale corpuscles must be nourished in order that they may be developed into red ones. And both pale and red must be nourished in order that they may elaborate fibrin, globulin, and hæmatin, out of the more crude albuminous constituents. Analogy marks it as probable, in the highest degree, that the blood corpuscles are first formed in the lacteal glands by the multiplication and division of the little cells that so abundantly line the lacteal vessels, where they pass through these glandular masses. No chyle globules appear in the chyle until it has reached the mesenteric glands, but immediately afterwards these globules present themselves. These globules, according to Mr Paget's views, are slowly and gradually matured into the red corpuscles of the blood. So soon as the pale corpuscles are completed they commence their vital operations by the formation of fibrin; the chyle becomes coagulable as its globules are constituted. But in

the useful manual of Drs. Handfield Jones and Sieveking will also prove a valuable guide to the student. But I am acquainted with no work more rich in important pathological facts, enlightened by the advance of science, than the "Transactions of the Pathological Society of London," which under the able editorship of Dr. R. Quain have now reached their sixth volume. I shall have frequent occasion to refer to them.

* For an able summary of the present state of knowledge on the subject of nutrition, see Dr. Carpenter's "Human Physiology," 4th ed., p. 556. To it and to Mr. Paget's Lectures I am chiefly indebted for the matter of the following paragraphs, which have been compiled by my friend Dr. Mann.

the ordinary course of affairs the pale globules develope into flattened corpuscles, cease to make fibrin, and form globulin and hæmatin instead. It is an interesting fact that in young animals and in pregnant females the pale corpuscles are unusually numerous in the blood. During the early formation of textures a rapid cell-multiplication out of the substance of the blood-plasma is necessary. Abundance of plastic fibrin for the extension and development of the mechanical parts of the frame is now required, and not of the richer globulin and hæmatin, for the vigorous support of the nervo-muscular apparatus. In the textural nutrition of adult animals, on the other hand, there is less call for rapid cell-formation, and less demand for fibrin, but there is more want of globulin and hæmatin. Hence, cells then develope, in the main, more than they multiply;—they have a longer individual duration, and maintain the vital operations by drawing the requisite material out of the blood-liquor through themselves. The rapidity of the process of cell-reproduction diminishes with advancing age, or if augmented under such circumstances, this is on account of some morbid influence or state.

But nutrition must be deemed, more or less, a vital process throughout. All germs can be artificially produced by the introduction of minute fat or oil globules into an albuminous liquid undergoing oxydation (§ 211), but the progressive development of these germs into perfect cells, able to perform all the various functions of separating certain matters from the blood, maintaining their own integrity, and of reproducing themselves, only takes place when all the arrangements of the living organism are present in full perfection. It is then only that the muscle and nerve cells appropriate the globulin and hæmatin that is conveyed to them, converting it first into their own substance, and then degrading it into creatine, creatinine, inosite, fat, and other low principles, and getting their own force during the process of degradation. Cell-life is concerned in all the nutritive and constructive operations of the frame. Not only do cells, the young and old corpuscles of the blood (pale and red), perfect the nutrient principles of the highest and lowest textures of the body, the globulin, hæmatin, and fibrin, as stated above; but cells also then assimilate those perfected principles. The grey vesicular masses of the nervous centres are composed of cells which undergo very rapid disintegration, and are no less rapidly reproduced. Nuclei are

found abundantly scattered amidst the muscular fibrils, designed, no doubt, to be developed into the contractile cells of which those fibrils are composed. The simple fibrous textures (connecting tissue, ligament and membrane), originate partly in fibrin and partly in cells, which are slowly converted into lengthened and condensed fibres by the fixation and further deposit of fibrin. Nucleated cells, or nuclei, with more or less fibrin, also constitute the basis of the other fabrics, which are more directly derived from the crude albuminous constituents of the blood, and are variously modified by growth and multiplication, and by the deposition of homogeneous or hyaline matter in their interstices. In some the cells are pressed together, and consolidated in rows and layers, as instanced in the epidermis, and in the epithelium of mucous membranes. In others the cells are enveloped in an amorphous or semi-organized fibrous substance of their own exudation, as in cartilage; or they become choked, and ultimately destroyed and replaced by earthy particles, which get arranged into the radiated and concentric laminæ of bone. When all the laws and conditions that are concerned in the formations and operations of cell-life have been more carefully studied, and more fully ascertained, it is to be hoped that many of the mysteries of structural disease will have been fathomed at the same time, and made plain. Already this much, at least, is clear, that fault in any of the attributes of cell-life furnishes an element of mal-nutrition, and renders unfit for its office the material that ought to be fit to form part of a living structure.

524. Since nutrition depends on the blood for its material, and on the supply of arterial blood for its activity, it may be anticipated that it must be modified by differences in the quantity and quality of the blood, and in its arterialization. It is in this way, when the onward development of the pale corpuscles into red ones is arrested, and fibrin is made out of substance that ought to be elaborated into globulin, hæmatin, and nerve-matter, that the various structural changes of inflammation are brought about. Diseases of nutrition are usually connected with diseases of the circulation and of the blood (§ 279): a moderately active circulation, and a rich state of circulating material, are favourable to healthy nutrition. Either too active or too feeble a movement, or poverty of blood, impedes it. Disordered quality or proportion of the several blood-constituents (§ 186, 211) renders it depraved. These

causes operate on the whole frame, and they commonly affect some parts and textures more than others, because the nutritive operations are naturally more active in them, and are therefore more readily influenced. Thus fat and cellular texture are increased or diminished more readily than muscle, muscle more readily than tendon or bone, &c.; and for similar reasons degenerations and other structural changes affect some parts more than others (§ 311.) But structural diseases are commonly limited and local, on account of some peculiar conditions in the affected part, and of these none are more frequent than such as act through its circulation. It is hence that partial anæmia, congestion, determination of blood, and inflammation, lead so often to limited structural disease. A similar remark has been made in regard to diseased secretion (§ 159) and other elements of disease. If the nervous influence affects nutrition, it is probably through its operation on the circulation. Thus a paralyzed limb wastes because, not being exercised, it is not so freely supplied with blood. The muscles of the limb of a frog, the nerves of which are divided, lose their irritability and waste also; but Dr. John Reid has shown that by exercising these muscles by electricity, which promotes the circulation, both their irritability and nutrition are maintained.

SECTION II.

INCREASED NUTRITION—HYPERTROPHY.

525. Hypertrophy, as a disease, is always partial; for although the whole body in cases of obesity acquires an enormous bulk, this is due to the extraordinary growth of the adipose tissue alone, one of the numerous textures of the frame. When the nutrition of the various structures has attained the highest point which health allows, there is no further increase of size in them, and the superfluous nutriment consequently accumulates in the blood-vessels, causing plethora (§ 276). Hypertrophy may affect *individual textures*, or *whole organs* composed of many textures: in the former case, it may be called *simple hypertrophy*, and is an ultimate element of structural disease; and in the latter, *complex*

hypertrophy, and is a proximate element. A few examples of both kinds may be instructively cited.

526. Muscles are enlarged by full exercise, alternated with a due amount of repose, a healthy and well-nourished condition of the blood being also present. Increased development of the voluntary muscles under such circumstances cannot be called disease; but I have seen it produce inconvenience when occurring in the sternocleido-mastoid muscle, long the seat of convulsive motion, in consequence of giving too great power to the muscle, and so tending to perpetuate the distortion. The best cure for this would probably have been Dieffenbach's operation of dividing the muscle, as employed in the case of squinting. Muscular hypertrophy is however chiefly productive of disorder when it affects involuntary muscles. Thus, when it occurs in the heart, in consequence of continued excitement in sthenic subjects, the violence with which the enlarged organ moves and propels the blood, produces bad consequences. The muscular fibres of the bladder become hypertrophied when there is difficult micturition from enlarged prostate, or from any other cause: those of the stomach and intestines do the same in consequence of strictures in the further part of the canal; those of the bronchi become so in spasmodic asthma. In these examples, (as in all others of true hypertrophy,) the increase takes place in the proper tissue, that is, in the muscular fibres: in what mode this happens, whether by the new formation of cell-germs and by their subsequent elongation into fibres, or by the splitting and growth of the original fibres, has not been accurately ascertained with respect to unstriped muscles; but Harting has shown that striped muscles grow by the increased size of the fibres, and not by their multipled number.

527. Hypertrophy of the interstitial filamentous textures of the lungs, liver, and other secernent organs, occurs after long continued congestion caused by disease of the heart (§ 311). When it affects the cellular texture of the lower extremities it appears to be a chief constituent of elephantiasis. Hypertrophy of the epidermis happens in callosities of the skin, and in corns, excited by continued irritation or pressure, which operates by causing determination of blood to the part. Another form of hypertrophy of the cuticle arises from chronic inflammation, and is instanced in psoriasis, chronic eczema, and impetigo. The cuticle is here retained, instead of being duly shed, and from its stiffness it often

cracks into chaps or rhagades. In the more temporary and slight cutaneous flushes, congestions, or inflammations of erythema, scarlatina, lepra, and pityriasis, superfluous epidermis is thrown off in a peeling of the skin, or in detached scales. But ichthyosis presents the most extraordinary example of this sort of hypertrophy in excess; in this disorder the dried epidermic cells accumulate in a solid state, so as to form scales, or coarse bristle-like projections. These affections of the epidermis have their parallels in diseases of mucous membranes; but the surfaces of these membranes being bathed with liquid secretion, the nucleated cells, which stand in the place of those that on the skin form solid scales, are here thrown off with the mucus, and are presented in it as floating shoals of epithelium scales, together with mucous cells and a viscid amorphous fluid (§ 455). Such disordered secretion of the mucous membranes not unfrequently co-exists with cutaneous diseases: thus, bronchial congestion with viscid expectoration commonly occurs in persons affected with psoriasis and lepra.

528. *Complex hypertrophy, or enlargement of organs* of a healthy kind may result from a more copious flow of blood being determined to them, in consequence of their increased use. It is thus that the uterus becomes hypertrophied in pregnancy: the breasts during lactation; and that one kidney becomes enlarged when its fellow is incapacitated by disease. The brain is developed in proportion to the exertion and activity of the mind; and when this is carried too far, if inflammation, congestion, or some other vascular disorder of its structure, is not induced, the organ is apt to become hypertrophied, until its bulk is too great for its bony case, its vessels get compressed, and it becomes indurated, and, as an obvious consequence, its functions are more and more impaired. Thus, in young subjects who have been remarkable for precocity and activity of intellect, the brain becomes over-nourished and too large, and fatuity and coma ultimately result. Mucous and cutaneous follicles sometimes acquire an extraordinary development after continued excitement, or even without any such obvious cause. Bursæ become enlarged in situations exposed to much pressure or friction, as, for instance, on the shoulders of porters, the knees of housemaids, the elbows of miners, and the ankles of tailors.

The hypertrophy of the liver and spleen so common in pro-

tracted ague, may very fairly be referred to the frequent repetition and long continuance of the enormous congestions which the disease induces in those organs (§ 310). I have known a similar enlargement in them to ensue after prolonged exposure to cold and wet. In some cases, however, where there is hypertrophy, no such external cause can be detected; the enlargement then must be referred to some peculiar condition in the circulation of the affected organs, or to an unusual activity in the molecules that nourish them. To this obscure category belongs the enlargement of the thyroid gland which is known as bronchocele.

The fatty enlargement or hypertrophy of the liver, and of adipose texture in general, may in many cases be referred to the ingestion of a large quantity of fatty food, or to a defective performance of those functions by which fat is eliminated from the system (§ 224); and in all respects the increase of this constituent must be viewed less as indicating a peculiar activity of nutrition, than as marking a predominance of its chemical material in the blood.

529. The general *treatment of* hypertrophy should depend on the pathological cause which has induced it. In most cases, this is some variety of hyperæmia, and the treatment suitable for the variety is to be employed, (see Congestion, Determination of blood, and Inflammation). But there are remedies which seem to be especially calculated to counteract the hypertrophy that is thus induced; such are iodine and its preparations, mercury, alkalies and their salts, and, in the more sthenic cases, sedatives and evacuants, conjoined with low diet. The same remedies are occasionally useful also in hypertrophy that is less distinctly connected with hyperæmia, such as bronchocele. It is always judicious practice to aim as much as possible at the removal of the exciting causes of the condition, as by tranquillizing the circulation in hypertrophy of the heart; by soothing irritations of the stomach, bladder, and other organs, in obstructive diseases of these viscera; and by changing the patient's residence in visceral enlargements connected with endemic influence. Hypertrophy of the heart calls for the use of judicious sedatives to moderate that excited action on which its undue nourishment depends; but care must be taken that the action is not too much reduced; otherwise its excitement is apt to be replaced by exhaustion, and hypertrophy by dilatation and degeneration. I have found much advantage from short

courses of iodide of potassium with liquor potassæ, or bicarbonate of potass and digitalis, followed by mild preparations of iron or other tonics. In many instances hypertrophy of the heart appears to be induced and kept up by the presence of an irritating matter in the blood; generally some excrementitious matter which ought to be thrown off by the kidneys. Hence the suitableness of the above-named remedies, which distinctly exercise a diuretic eliminative operation. I am quite sure that simple hypertrophy of the heart is sometimes removed under these and similar means.

SECTION III.

DIMINISHED NUTRITION—ATROPHY.

530. Atrophy, unlike hypertrophy (§ 525), may be a general disease; that is, all parts of the body may waste together, so much as to impair their functions. *General atrophy, marasmus,* or *emaciation,* consists in the removal of a considerable quantity of the textures of the frame by decay and absorption without an equivalent reparation by nutrition (§ 523). The organic materials of the body are not persistent, but are, more or less, prone to decay, and become effete or worn out in a limited period of time: or, as Dr. Alison expresses the same fact, the vital affinities which hold their elements together, cease to be operative, and so they become subject to common chemical affinities which tend to the dissolution of their molecules; the oxygen conveyed into the blood by respiration being a chief instrument in their decomposition. But in the healthy body there is a reparative process continually countervailing this decay, by the deposition of new materials whose vital affinities are energetic, and therefore able to maintain the integrity of the textures (§ 523). Hence the causes of atrophy may be divided into circumstances which promote decay, and those which impair or prevent reparative nutrition. Among the former may be ranged various influences which exhaust generally, such as excessive and prolonged exertion, or excitement, want of sleep, extreme anxiety of mind, or continued suffering; under the prevalence of these, a person is familiarly said to be "worn to a shadow," without any more distinct disease taking place. On

examining the urine in such cases, it will often be found to contain an excess of urea, resulting from the decay of the textures. The secretion also presents alkaline characters, and is unusually prone to decomposition; and the intestinal and cutaneous excretions exhibit an uncommon fœtor, arising from a similar tendency to putrescence. Fever of a low or hectic kind may be excited as a result of these changes, and be then mistaken for the cause of the wasting. In cases of marasmus induced by excessive secretions or drains from the body, there is often also evidence of accelerated decay: thus, diabetes mellitus reduces the frame not only by the perversion and removal of its nourishment (§ 255), but also by promoting the decay of its textures, manifested in the increased amount of urea excreted. Fevers and various acute diseases attended with much excitement, exhaust the vitality of the textures, and promote their decay, in like manner, and they do this especially as the disease declines, when the emaciation becomes most obvious.*

There are several circumstances which may impair or prevent reparative nutrition, and these may be effective in any or all the stages of the nutritive process, from the reception of food into the system to its appropriation by and assimilation to the living textures. As examples in this series may be mentioned—1. Defective quantity or innutritious quality of food (§ 58, *et seq.*); 2. Disorder of some part or parts of the digestive apparatus, such as occurs in severe dyspepsia and diarrhœa, which prevent the due elaboration of the chyle; 3. Diseased mesenteric glands, or tumours obstructing the thoracic duct, whereby the supply of chyle to the blood is intercepted; 4. Perversion of the elaborating process through which chyle is converted into blood (§ 253), as instanced in diabetes mellitus and chylosus; 5. Defect in the formation of

* My friend Dr. Hodgkin considers a suspension of textural nutrition to be a chief cause of the phenomena of fever, and has very ingeniously applied this notion to explain many of its symptoms.—Lectures on Morbid Anatomy of Serous and Mucous Membranes, vol. ii. p. 490. Rokitansky and other German pathologists think that typhoid fevers depend on the production in the body of an organic matter which has some resemblance to malignant formations. To this they apply the term typhus-material, and they point to the follicles of the intestines and the parenchyma of the lungs as the most common places of its deposition. Under the microscope, however, this matter exhibits no character that can distinguish it from bad fibrin or cacoplastic lymph; and in accordance with the view given in the text, I consider it to be such, and tending to involve in a process of sloughing the excretory follicles of the intestines in the attempt to be thrown off, or inducing a deposit in the lung which has various pernicious tendencies (§ 474).

fibrin (§ 196), hæmatin, and globulin out of the more crude albuminous constituents of the blood, so that instead of becoming plastic material for repairing the texture, they have a tendency either to pass rapidly into decomposition, as in malignant fevers (§ 257), or to concrete in a cacoplastic or aplastic form, as in tuberculous diseases; 6. Excessive discharges of various animal fluids, such as blood, pus, serum, milk, semen, or mucus; and morbid growths, which monopolize the nourishment of the body, such as tumours of various kinds; particularly cancer; 7. Parasitical creatures, such as hydatids, worms, &c.

531. A consideration of the above series of causes of emaciation will suffice to show how uncertain it must be, as a symptom, if it be taken alone; but when traced to its source, it becomes a very important indication of the extent to which that cause operates on the living body. Emaciation rarely continues, or advances to an extreme degree, without structural changes which render the cause of the mischief permanent: hence extreme marasmus is generally connected with tuberculous disease, carcinoma, (especially of the stomach,) or some serious organic lesion. The chief exception to this is diabetes, the intractable persistence of which still remains involved in much obscurity.*

532. *Partial atrophy*, the reverse of partial hypertrophy (§ 528), commonly arises from defective supply of blood to the part. Sometimes the defective supply is a consequence of the disuse of the part: thus it is that the eye wastes in confirmed blindness; that muscles and whole limbs become atrophied in paralysis and anchylosis; that the testicle and the mamma waste with age, &c. Frequently partial atrophy in an organ succeeds the changes induced by inflammation or other structural disease; the matter effused swells some parts, and so compresses others of the texture, and preventing a due supply of blood, causes a subsequent atrophy. This is especially the case when the products of inflammation or congestion are cacoplastic, as in cirrhosis of the liver and granular disease of the kidney, and in the consolidation of the lung from

* Saccharine diabetes is not however always a continuous disorder; for in some cases the sugar will for a while entirely disappear from the urine, and reappear without any very obvious cause. In some instances of this kind the urine becomes quite natural in the interval, but in others it retains a high specific gravity, due to the presence of some organic matter, which is neither sugar nor urea. In several cases not strictly diabetic I have known sugar to appear in the urine for a time: but as these are unattended with emaciation, they hardly belong to the present subject.

pleuro-pneumonia: the deposits here tend mechanically to contract and compress the vascular structures, and so to deprive the organ of its nourishment; it accordingly shrinks in size, or, in the case of the lungs, the texture may become thin and emphysematous. In chronic pneumonia and phthisis, also, many of the pulmonary blood-vessels become obliterated, and the parenchymatous texture either wastes or further degenerates, according to its condition. Atrophy of the heart and brain has sometimes been found to be connected with ossification and partial obstruction of the arteries supplying them. The dwindling of limbs in children, and the lameness in old persons dependent upon shrinking of the neck of the thigh-bone, appear to be induced in a similar way by impediments in the vessels supplying the parts.

533. The *treatment of general atrophy* (§ 530) should be directed to remove or obviate the cause, where that is practicable, to supply proper and adequate nourishment, and to promote the healthy action of the digestive, assimilative, and circulatory functions. The means by which these indications can be fulfilled, are too varied to be introduced here in detail: it must suffice to mention the chief remedies and measures that are influential in counteracting the several pathological causes of atrophy.

Atrophy, from excessive or prolonged exertion, is best treated by increased rest and nourishment, adding to the latter wine or other stimulants if exhaustion continues present (§ 84); that from anxiety of mind, prolonged suffering, or sleeplessness, by various medicinal narcotics, change of air and scene, and such other measures as are calculated to soothe under the particular circumstances. The effect which opiates and other narcotics occasionally exert in diminishing the quantity of urea excreted in such cases, points out that these medicines tend to control decay, and their influence may sometimes be aided by mineral acids and tonics of various kinds. The same remedies are useful in diabetes mellitus, but the arrest of the marasmus may then, however, be furthered by withholding *all* articles of food which can be converted into sugar—that is, such as are of a farinaceous, amylaceous, saccharine, and gelatinous nature (§ 256). I have generally found that the excessive discharge and the emaciation of diabetes are effectually controlled by the full observance of this rule, but not by its partial adoption, as recommended by Dr. Prout.

The treatment which is best suited to counteract the circum-

stances that impair or prevent reparative nutrition (§ 530) has been already alluded to when speaking specially of the several diseases and causes of disease classed under seven heads, in paragraph 530, and it would therefore be superfluous to dwell long on the subject here. The use of food as nourishing as the stomach can digest, and of tonics, medicinal and hygienic, as bracing as the body can bear, with due regulation of the excretions, affords the best chance of arresting or retarding the emaciation; but the utility of these proceedings depends a great deal on the judgment with which they are directed. The utility of fat in the process of nutrition has been several times spoken of (§ 66, 211, 224); in addition to a fair allowance of milk, butter and fat as articles of food, or instead of them, if they disagree, the cod-liver oil is a valuable adjuvant. Cod-liver oil is best suited to scrofulous cases, but I have seen proofs of its utility in various kinds of emaciation, especially in convalescence from fevers, and from prolonged and wasting attacks of rheumatism.*

534. As *partial atrophy* sometimes arises from defective circulation in a part, it may occasionally be remedied by the adoption of measures that are calculated to promote the passage of blood through it. Muscles that have wasted under disuse are sometimes strengthened and made to increase by blisters, stimulant frictions, electricity and exercise. Atrophy following inflammation or congestion may often be advantageously treated by the remedies that are appropriate to the results of these conditions, and especially by iodine in combination with tonics, as the iodide of potassium with sarsaparilla, iodide of iron, &c. In most cases of structural disease treatment can do little to remove partial atrophy already induced, but it may retard its increase by restoring a more healthy state of circulation throughout the body.

* As there is some reason to believe that certain inorganic matters are concerned in aiding the process of nutrition, it may not be thought irrational to suggest their trial in obscure cases of general atrophy, although we may be ignorant of the mode in which they operate. I would particularize lime, phosphoric acid, and fluoric acid. Lime, in form of lime water, has long been used as an adjunct to a nutritious diet, and it exists in considerable quantity in most kinds of spring water. Phosphoric acid has been already recommended as a medicine, and in a diluted form it may be made an agreeable beverage. An agricultural friend of mine has employed the fluoride of sodium as an aid to nutrition in some of the lower animals, and he thinks with good effect. I have sometimes seen a prescription of fluoric acid for a human patient: but with its power of attacking glass, it is not likely that it ever reached the stomach of the patient. If administered at all it should be in the form of fluosilicic acid, which may be kept in glass vessels.

SECTION IV.

PERVERTED NUTRITION.

535. Under this head are comprehended all those changes of structural nutrition that go beyond mere *plus* and *minus* influences upon the natural molecular constitution of textures; either the *quality* of the fabric is altered, or new tissues, growths, or deposits are formed in connexion with the normal texture. Partial hypertrophy and atrophy often coexist as well; and when they do so, the observations already made with regard to those elementary changes may be extended to these, but with new additions.

INDURATION AND SOFTENING.

536. *Induration* and *softening* have both been named as occasional results of inflammation; softening being commonly connected with the increased secretion and absorption that occur in acute inflammation (§ 427); or during the liquefactive process of suppuration (§ 461); and induration being rather a sequel of the more chronic affection, which causes a continued overflow of solid plastic matter (§ 479). Both these changes sometimes take place independently of complete inflammation; but they probably are in most cases connected with some of its elements.

537. *Induration* may be caused by an increased deposit of solid matter in a structure, or by compression of that structure, or both conditions may combine. In some forms of insanity, the inner table of the skull acquires the hardness of ivory. In newly-born children, the skin occasionally acquires unusual hardness and rigidity, making their little bodies "skin bound." Glands and other soft compound organs sometimes become hard without inflammation. Probably, in all these cases, there is prolonged determination of blood to the parts, and hence an exaggeration of the nutritive function; but the matter exuded is more hyaline (§ 523), or simply granular (§ 452, 3), rather than consisting of highly organized cell-germs or fibres; hence the result is not simple hypertrophy or increased growth, but a more condensed and homogeneous texture. A somewhat similar change is produced in the lung by compression from liquid effusion or by a solid tumour, especially when the organ itself is also inflamed, as it is in pleuro-pneumonia, where the

pressure restrains the full development of the exudation corpuscles. The induration of cartilage, &c., by osseous deposit, is more properly transformation than simple induration. So too induration of the liver, kidneys, and other analogous organs, is generally accompanied by interstitial deposits, and other changes of structure.

538. *Softening* arises from different causes in different textures. In some instances the cause, being peculiar to the structure, may be called specific. Thus in the bones the change proceeds from a substitution of fat in place of phosphate of lime, the earthy matter which is destined to give them solidity.* The softening of the stomach commonly found after death results from the solvent action of the gastric juice. The softening of various textures, and especially of the muscles, in fevers and other cachectic states, is connected with a defect of fibrin and globulin in the blood (§ 196): the same cause which removes or prevents the formation of these plastic matters (§ 216), apparently dissolves or loosens the more solid parts of textures. In several cases of cachectic disease in intemperate persons, where there was degeneration of the liver and kidneys, I have found after death a general softening of the solids, and an unusual abundance in them of oil globules, readily detected by the microscope (§ 258). In other instances, softening is a variety of atrophy arising from a defective supply of blood; so that the texture of the part decays, and is absorbed away faster than it is repaired. Softening of the brain and heart is thus sometimes found to be connected with fatty or calcareous degeneration, and partial obstruction of the arteries supplying those organs.† Softening of the affected muscles occasionally accompanies paralysis, especially when it is caused by the poisonous influence of lead. Partial softening, as well as atrophy, now and then follows inflammation, and is under such circumstances to be ascribed to the obstruction of the vessels which the affection has produced. In this way softening of portions of the brain is induced by meningitis; softening of the heart occurs after pericarditis; softening of the stomach and intestines after some kinds of gastro-enteritis; and softening of the articular cartilages after their inflammation. In general terms, therefore, softening may be

* Dr. Garrod, Trans. of the Pathological Society of London. 1847, 8.

† For examples, see Transactions of the Pathological Society of London, Drs. Quain and Sibson; vol. iii. p. 242 and 246. Dr. Kirkes, Med. Chir. Trans., vol. xxxv. p. 281. Mr. Shaw, Pathol. Trans., vol. iv. p. 29.

described as a variety or degree of atrophy, characterized by more or less change of solid into fluid or semi-fluid matter. In most instances the fluid exhibits an abundance of fat globules, which establish the affinity of softening to fatty degeneration, to be noticed hereafter, as a result of degraded nutrition.

Although in all cases of partial softening, the cause is chiefly local, yet a nonfibrinous or aplastic condition of the blood materially contributes to the result; and it is a matter for serious consideration whether the continuance of antiphlogistic measures and abstinence may not occasionally promote this change. Some of the most distinct cases of softening of the heart and brain that I have met with, have occurred where the patients have been long kept in a reduced state for fear of a return of inflammation to these organs.

539. Induration and softening being opposites of each other, although sometimes preceded by similar causes, require, to a certain extent, parallel modes of *treatment*, but in an opposite way. Induration, consisting of condensed hypertrophy, and often arising from prolonged determination, may be best attacked by partial antiphlogistic measures, especially such as tend to remove obstructions and deposits (§ 511, 515). Thus mercury and iodine, externally and internally used, and alkaline saline medicines, seem to possess some power to disperse hard swellings; and setons, issues, or suppurating counter-irritants, which draw away blood and nutriment from the indurated part, are in some cases found to be serviceable. But extreme antiphlogistic or reducing measures are not advisable (§ 218), inasmuch as induration itself implies already a degradation of the nutritive material (§ 537), and does not result simply from acute or sthenic inflammation.

540. In cases of softening that are not specific (§ 538), the appropriate indications of treatment are, to restore a more fibrinous or plastic state of the blood, and to improve the circulation in the atrophied part. In fevers and cachectic states, where the softening is general, the first should be the principal aim, and some of the means of fulfilling this have been already noticed (§ 216). Besides nourishing food, and the employment of agents which improve the digestion and circulation, tonics and stimulants are often of use. How far the operation of mineral acids, bark, and other similar tonics may depend directly on their astringent or bracing influence upon the animal fibre, it is not easy to determine; but after

fevers, and in cachectic states, these agents certainly do appear to improve the quality and firmness of the solids in some more immediate way than by merely exciting the circulation, and ameliorating the condition of the digestive organs. So, too, the operation of stimulants, both local and general, probably goes beyond that which is simply incident to accelerating the circulation, and determining blood to parts where it is ill supplied: it probably also increases the production of fibrin and corpuscles at the expense of albumen, just as we see the same to result from the application of stimulants before they cause inflammation (§ 294, 415). The relief sometimes afforded to the symptoms of softening of the brain and heart, where all inflammation has ceased, by the administration of mild stimulants, tonics, and a moderately nourishing diet, is too little known to those who have always the dread of inflammation before their eyes, and who yet forget that a chief evil of inflammation is the injury it inflicts on function and structure, which endures even when the inflammation is gone or when it is but of trivial amount. The beneficial effect of nourishing diet and stimulant applications on soft, flabby ulcers is another argument in favour of the adoption of the same kind of treatment in cases of internal disease, where the general weakness, apyrexia, pallidity, and muscular emaciation preponderate greatly over the symptoms of local irritation. The principal benefit arising from the use of stimulants and tonics may be fairly traced to their promoting the healthy formation of blood, and to their causing an increased vigour of circulation; but there are some agents which seem to augment the plasticity of the blood, without exerting any remarkable tonic influence. Such are nitric acid, nitromuriatic acid, and chlorate of potass, the powers of which to promote the healing of cachectic or spreading ulcers are very decided; I have also obtained much advantage by the employment of these medicines in various cachectic states, following prolonged acute disease, or habits of intemperance. It seems probable that they act chiefly by supplying to the blood the oxygen necessary for the formation of fibrin (§ 211) or deutoxide of protein, or for other processes of vital elaboration; the respiration in its weakened state being inadequate to furnish a due amount. The purest air, and such muscular exercise and superficial friction, as may tend to make the respiration and circulation more effective, are beneficial in these cachectic states on a similar principle.

541. The treatment of the specific kind of softening which is apt to affect the bones is not yet satisfactory. The circumstances which promote or impede the deposition of phosphate of lime in the osseous texture, are not clearly made out; but measures of a tonic nature combined with appropriate nourishing diet, have been found to be decidedly useful in the rickets of children. The mollities ossium of adults is a yet more obscure affection, and comprising as it does so entire a perversion of the natural process of nutrition of bone, it is hardly to be wondered at that it should prove intractable. The constant presence of fluoride of calcium and silica in bone suggests the possibility of their being concerned in promoting the deposition of the phosphate of lime; the fluo-silicic acid might therefore deserve a trial in this unmanageable disease. The formation of callus at the ends of fractured bone, and the completion of the ossific process in it, are without doubt promoted by generous diet and tonics.

SECTION V.

TRANSFORMATION AND DEGENERATION OF TEXTURES.

542. When one elementary texture is replaced by another, as, for instance, when muscle becomes simply fibrous structure, it is said to be *transformed*. The term *degeneration* is also commonly applicable to the change; because the substituted texture is mostly, as in the case alluded to above, lower in vital character than the one that is replaced. The chief exceptions to this are, the transformation of skin into mucous membrane, when by anchylosis of a joint an external surface is brought almost to the condition of an internal one; and the transformation of mucous membrane into skin, when the uterus has been long prolapsed. In these instances, the changes appear to arise from the physical condition in which the texture is placed: the exudation corpuscles remain soft and moist, and become epithelium scales and mucous globules in one case, and they dry into epidermic layers in the other. It is not so much that one structure is transformed into the other, as that one rudimentary base is developed into different forms by the agency of the special circumstances to which it is exposed.

Muscle is sometimes changed into simple fibrous or fibro-

cellular texture, after the inflammation of contiguous parts. Loss of muscular substance, in consequence of wounds or from ulceration, is generally replaced by a similar fibro-cellular texture, and never by new muscles.

543. Animal textures are liable to various kinds of degeneration; of these four may be particularly specified as having distinctive physical and chemical characters; they are the *fibrous*, the *granular*, the *fatty*, and the *osseous* or *calcareous*. All present features of deterioration or degradation in the scale of organization, as is implied in the term *degeneration;* and this degradation takes place in the order in which the four several forms are arranged above. In chemical composition, and in a fainter degree, in physical condition, the series analogically presents a successive descent from animal, through vegetable, to mineral composition.

Fibrous degeneration chiefly affects muscular structures, and especially occurs when inflammation has existed long in or near them. Thus parts of the muscular fibres of the heart have been found converted into a dense fibrous tissue after endocarditis and pericarditis :* the same thing has happened to the muscles of the limbs after prolonged fascial rheumatism; and to the intercostal muscles and diaphragm in chronic pleurisy. Age ordinarily works a similar change, as is illustrated in the tough and sinewy condition and wasted size of the muscles of old animals (§ 48). The fibrous tissue thus formed resembles that existing naturally in the tendinous and fibrous structures of the body; it consists of closely knit bundles of fibres, which, however, have a scantier distribution of nuclei, and very few blood-vessels amongst them. The fibres are usually also coarser, and here and there present granular irregularities. They often exhibit a tendency after a time to degenerate into the yet lower forms of degraded substance;—the granular, the fatty, and the osseous. In chemical composition the fibres belong to the gelatigenous group of tissues. Several parenchymatous organs, particularly the spleen, the liver, the kidneys, and the lungs, are occasionally affected by a change which seems to amount to fibrous degeneration, a dense filamentous tissue pervading, and more or less superseding, their natural structures; but as in all

* I have notes of several cases in which this fibrous degeneration had taken place in the interior of the heart. An example occurred in the case of a gentleman from India whom I saw with Dr. James Bird, and a notice of the appearance may be found in the Trans. of the Patholog. Soc., vol. iii. p. 276.

these instances there is a great increase in the density of the organ, it seems to be more correct to view the new fibrous material in the light of an interstitial deposit, rather than in that of a transformation of the proper textures. This will be again considered under another head.

544. *Granular degeneration* is also frequently met with in various organs, and is, like the structural change just noticed, the result of a cacoplastic deposit in the interstices of a texture; but this exhibits a granular instead of a fibrous character. The same appearance is sometimes induced under the deteriorating influence of mal-nutrition, chronic inflammation, and old age, when there is no augmentation of substance. It has been just now remarked that morbid fibrous tissues sometimes tend to this condition. But the same state of things may take place in the normal fibrous and elastic textures, especially those that form part of the vascular apparatus, impairing their cohesion and transparency, and rendering them liable to undue extension, laceration, and rupture; or constituting the first stage of a yet further degeneration into fatty or calcareous matter. Under the microscope the structure presents a remarkable increase of aggregated granules, and a corresponding diminution of the fibrous or filamentous element. The granules are not highly refractive, and there are no free oil globules; in these respects the condition differs from fatty degeneration; the material is neither so opaque nor so fragile as the true fatty atheroma. This form of degradation is probably intermediate between the fibrous and the fatty or osseous forms; I have repeatedly observed it in the walls of an artery which presented both these kinds also. The chemical composition of degraded granular structure is not certainly known; but it is probable that it is either of a gelatinous or albuminous nature, and is mixed with molecular fat. Cacoplastic deposits and recent lymph sometimes degenerate in this mode.

545. *Fatty degeneration* was long since described by Laennec as affecting the muscles, the liver, and some other structures. It is to be carefully distinguished from fatty accumulation, which is merely hypertrophy of the natural adipose tissue, and which may by its bulk press on textures, and cause them to waste. True fatty degeneration consists in the conversion of the proper tissue of the part into fat; thus in fatty degeneration of muscles, the fibres themselves become pale in patches or spots, and under the micro-

scope exhibit fatty globules or granules within the sarcolemma; as the change increases, the colour and consistence of the muscle are impaired, and its power is proportionately weakened. This change has been found in the heart, and in the voluntary muscles, under circumstances somewhat analogous to those which promote the fibrous degeneration of the same textures: but apparently it occurs in connexion with still weaker constitutional powers, and with other evidences of impaired circulation and marked mal-nutrition. In these cases, as well as in some others, the arteries exhibit the atheromatous patches that Mr. Gulliver has proved to consist of fatty matter, which appears to be partly formed at the expense of the middle coat, and to be partly deposited in granules and globules under the inner lining.

To the preceding description, which appeared in the former edition of this work, some important additions may be made from researches since published; especially those of Dr. R. Quain (*Med. Chir. Trans.*, vol. xxxiii), whose essay gives a far more complete account of the subject than any that had appeared previously. His observations have reference more especially to fatty degeneration of the heart, which he distinctly proves to be an intrinsic conversion of the muscular fibres into fat; and to be the result of imperfect nutrition, in some instances in consequence of more or less obstruction of the coronary arteries. Dr. Quain has shown that sudden death in connexion with diseased heart is especially due to this lesion.

Mr. Paget has observed fatty degeneration in the arteries of the brain in cases of apoplexy and softening of the organ; the change being obvious under the microscope, even when there was no appearance of ordinary atheroma. Dr. R. Hall has recently noticed the same condition in the branches of the pulmonary artery in connexion with tuberculous disease of the lung (*Brit. and For. Med. Chir. Rev.*, Oct., 1855). The fatty degeneration of a certain portion of the cornea and iris has been shown by Mr. E. Canton to constitute the *arcus* or *circulus senilis*, which is often an important visible sign of the tendency to this degenerative change in the system. I have found it present in about nine-tenths of the cases in which I had reason to infer the existence of fatty degeneration of the heart. But the arcus senilis is commonly seen, as the term implies, in aged persons, and in those also who are prematurely old through much anxiety or

mental labour, or through prolonged habits of dissipation. It has likewise been observed as a sequel to protracted disease in the eye itself. Fatty degeneration has been found in several other organs, generally in connexion with other changes of structure, impairing the nutrition and function of their natural tissues; for example, in the liver, kidneys, pancreas, stomach, urinary bladder, and the placenta. But a similar conversion into fat appears also to attend certain processes of a salutary kind: thus, the removal of solid inflammatory deposits seems to be aided by their partial conversion into fat,* and Kilian and Rainey have distinctly shown that the muscular substance of the uterus is removed in this way after gestation.†

Fatty degeneration of the liver is characterized by the pale opaque appearance of the viscus, by its low specific gravity (so that it sometimes floats in water), by its soft greasy consistence, and by its greasing paper when heated upon it. Mr. Bowman pointed out that the liver cells naturally contain a considerable quantity of oil globules; and he suggested that fatty degeneration might here depend on an increase of this normal constituent, to such an extent as to press on and to cause the atrophy of the other tissues. It has been surmised that this oil is the principal material out of which the bile is formed by the secreting cells; that its great increase in phthisis is mainly due to the accumulation in the blood of hydrocarbon which the lungs ought to remove, but cannot, in consequence of their diseased state; and that this accumulation is chiefly found in the liver because it is that organ's office to fit the effete hydrocarbons for removal through the pulmonary exhalents. But if this explanation were correct, fatty degeneration of the liver would occur more constantly in phthisis and other diseases of the lungs than it does. I have met with it chiefly in females in whom emaciation has proceeded with great rapidity; and I should rather be inclined to ascribe it to the accumulation of fatty matter, which is taken into the blood in consequence of the rapid decay of the textures, and is conveyed to the liver as the proper organ for its excretion. It is also most probable that the fatty matter which is formed in tubercle, during its process of maturation and softening, may be absorbed into the circulation, and may so contribute to this change in the liver.

* Paget's Lectures, Med. Gaz., vol. xlv.

† Trans. of Pathol. Soc. Lond., vol. iii. p. 396.

But fatty transformation occurs also in other organs and tissues so commonly as to show that it must arise from some chemical tendency in animal substances, independently of the function of any particular organ. Thus we have already (§ 223, 258, 538) alluded to instances in which fat globules are found in increased numbers in various organs of the body, without there being any marked development of the common adipose textures. This has been noticed to occur in the bodies of persons who have been habitually intemperate, especially in connection with disease in the liver, with or without jaundice; but I have also met with a few such cases in cachectic subjects who have not been addicted to excesses, and in these the urine has usually been albuminous, and the kidneys have exhibited more or less of the degeneration first described by Dr. Bright. In these examples, all the viscera which I have examined have presented an unusual abundance of oil globules, with some degree of softening, and the opaque yellowish paleness, common to ill nourished tissues; the liver, spleen, kidneys, and even the muscles wearing a dingy red, or yellowish brick hue, instead of their proper colours. The increase of oil globules in the epithelium-cells of the kidney has been noticed by many observers,* particularly by Dr. George Johnson, who at first considered it to be the primary pathological change in Bright's disease of the kidney, corresponding with fatty degeneration of the liver; he also ascribes the impaired function and wasted structure of the organ to this accumulation of fat. But it is now generally admitted that although in many cases of Bright's disease there is a great increase of fat in the cortical structure of the kidney, yet in other instances this is not the case; the granular degeneration being rather dependent on the accumulation of fibrinous matter in the tubules and cortical substance, than on the presence of fat.

In fact the same increase of fat globules which is noticed in these cases in the kidney is found in other textures, and is the result of a chemical change which tends to convert animal substances in general into fatty matter. A similar tendency is manifest in the products of inflammation and other deposits. Thus the opaque exudation corpuscles found by Mr. Gulliver in great

* The earliest observations of fatty degeneration in the kidneys, seminal tubes, and several other organs, were made by Mr. Gulliver.—Edin. Med. and Surg. Journal, July, 1843.

abundance in lungs affected with low inflammation (especially if chronic), and with gangrene, were ascertained by Dr. Davy to consist chiefly of olein and margarin. The pus of old abscesses, mature and softened tubercle, fibrinous vegetations on the valves of the heart, and the softened fibrin found in blood-vessels or on serous surfaces that have been long inflamed, also contain a very large proportion of fatty matter in a crystalline, granular, or liquid form. The following extract from Mr. Gulliver's notes to Hewson's works bears on the same point. "In Dr. Benjamin Babington's observations, the specific gravity of the milk-like serum of the blood appeared to be so regularly reduced, as to lead him to believe that the oil exists at the expense of the albumen. There are some facts in favour of the idea that albumen may be converted into oil. The rapid disappearance of the matter of the curd of perfectly fresh salmon, with the subsequent more oily state of this fish, may be owing to a conversion of this kind, according to the conjecture of Sir Humphry Davy, as I have learnt from Dr. Davy. I have observed that the oil of the liver of several fishes increases after death, probably in connection with incipient putrefaction; and Dr. Davy informs me that in the liver of the cod, after it had been kept in a damp place for twenty-five days, he found a small increase of oil, with the formation of carbonic acid and ammonia at the same time."—(p. 86, *note*.)

But there is no chemical fact, which throws so much light on fatty degeneration, as that of the formation of adipocire from animal flesh when kept moist without access of air. I directed attention to this analogy in the first edition of this work; Dr. Alison soon after, in his essay on "Vital Affinities," (Trans. of Royal Soc. of Edin. 1847,) proposed a formula by which the conversion of albumen and water into fat and carbonate of ammonia, may be readily explained.

The chemical view of the nature of fatty degenerations thus advocated in the former editions of this work has now been completely established by the observations of Dr. R. Quain. He has produced the fatty conversion in healthy muscle by simply keeping it for a sufficient length of time in water to which a little nitric acid or spirit had been added to prevent putrefaction. After some days, oil globules appear in the fibres of the muscle, and gradually increase until much of the sarcous element is converted into them; and under the microscope, or to the action of chemical

tests, the change is proved to be identical with fatty degeneration as it occurs in the living body.*

The circumstances under which fatty degeneration mostly takes place, greatly favour the view that has been propounded above, of its being the result of chemical affinity. As a *general* disorder, or *affecting many organs* at once, it occurs in connection with a feeble circulation and with low respiratory powers; and it is promoted by conditions which increase the quantity of hydrocarbon of the blood, whether these be dependent upon habitual indulgence in alcoholic stimulants and the like; or upon the imperfect removal of biliary matter from the system. An increase of fat, and especially of cholesterin, has been observed in the blood of aged persons. Fatty degeneration affecting a *particular organ* (except in the peculiar case of the liver), is commonly the result of previous disease having impaired the freedom of the circulation through it, and often of its having left a granular or other cacoplastic deposit in its interstices, which not becoming fully organized, nor receiving the renovating and oxidating influence of the circulating blood, gradually passes into the condition of fat, the lowest principle in the scale of animal compounds, and one that approaches to the nature of the simpler vegetable matters in the entire absence of azote. The same change may ensue more gradually from the failing circulation and respiration which attains in advancing age (§ 48); and it will be accelerated in any texture or organ whose structure has been injured by previous disease, accident, or disuse.

Under whatever circumstances the fatty transformation occurs, it is obviously a process of degeneration, or degradation to a very low scale of animal life; its occurrence in gangrene is a striking illustration of this fact; the vital properties of the organs which it invades become lowered, and the mechanical qualities also are greatly impaired. Thus muscles, so degenerated, lose much of their contractile power, and if subjected to distension, as they are in the heart, become dilated, and may be even ruptured. The tonic and elastic fibres of arteries also suffer in their elasticity, and yield in pouches, or become lacerated, or in process of time petrified.

* Dr. Hodgkin and I had previously observed instances of a decided increase of fatty matter in morbid specimens after death; and I had requested my clinical assistant, Mr. Edward Palmer, to make experiments on the subject, by keeping portions of organs in a moist state excluded from the air, as I expected a change analogous to that of adipocire would be found in them.

Glands and secreting structures lose much of their secernent activity, and their cells, vessels, and ducts get to be clogged and deranged in their functions by their fatty contents, especially when these assume the solid form. Parenchymata and interstitial tissues suffer from the same cause in their properties of softness and cohesion, and in the freedom of their circulation, and also become liable to the further changes of disintegration, and to calcareous deposition, which is the last kind of degeneration to be noticed.

546. *Calcareous* or *osseous* degeneration approximates the structure which it invades to the character of a mineral, and hence might not inaptly be designated by the term *petrifaction.* The tissues that are most liable to the change are such as are low in the scale of organization, and yet constantly moistened by the blood liquor, as for instance cartilage, fibro-cartilage, fibrous tissue, and similar structures that are the results of disease. Morbid ossification has been commonly compared to the natural process by which bone is formed; but it resembles that process little more than in the deposition of solid phosphate of lime in the interstices of the tissue: where the tissue itself approaches to the nature of bone, the result may present a near approximation to true osseous structure, as is the case with ossified cartilage: but when it is the cardiac valves that are affected, the calcareous matter forms plates and masses which have only a remote affinity to the structure of bone.* In fact the most complete specimens of petrifaction gradually supervene upon the deposit of aplastic fibrin in lymphatic glands, in the lungs, on the surface of serous membranes, and on and under the lining membrane of arteries; if these deposits escape fatty degeneration and softening, they are very apt to be ultimately converted into masses or plates of calculous or stony matter, in which there may be little or no animal substance. This process is therefore to be viewed as almost entirely of a chemical nature, and as consisting in the concretion and accumulation of calcareous salts, phosphate and carbonate of lime, in the debris of animal matter. It is uncertain whether this calcareous matter is the insoluble residue of successive acts of deposition and absorption; or whether it is the result of degenerating

* Dr. Hyde Salter has traced in the structure of some of these osseous deposits a resemblance to that of dentine. Trans. of Pathol. Soc., vol. v. p. 35: see also vol. vi. p. 300.

albumen exerting a chemical attraction over the phosphate of lime in adjoining fluids; but the latter seems the more probable notion, and it is indeed strengthened by the fact that a similar petrifaction sometimes occurs in loose cartilages in joints, and in detached concretions in veins, (phlebolites). Andral and Dr. Carswell are of opinion that these concretions are produced by the gradual ossification of little clots of blood, which are first consolidated and then ossified.

The petrifactive process is essentially a slow one; and, as a spontaneous change, occurs most in advanced age; but, like other forms of degeneration, it may be induced and accelerated by inflammation, especially when it is of a chronic kind. Thus the cartilages of the ribs, and of the air-tubes, and the walls of the arteries, are generally more or less ossified in old people: the same changes are also very apt to occur in earlier life, in consequence of repeated or prolonged attacks of inflammation in adjoining parts.

It is scarcely necessary to point out the various modes in which morbid ossification tends to injure the structure and function: it renders the textures that it attacks rigid, inflexible, inextensible, inelastic, and therefore brittle and obstructive. It is this degeneration in particular which stiffens the gait, shortens the breath, and weakens the circulation in advanced age (§ 48), and which makes the frame unfit to bear shocks or sudden changes, that it is capable of resisting when possessed of the pliancy, elasticity, and varying powers of earlier life. And so the same change induced by disease in a particular apparatus, such as that of the respiration or circulation, reduces that apparatus to the limited capacity of decrepitude: thus a young or middle-aged person with asthmatic breath or crippled circulation, is to this extent prematurely old, and indeed encounters more suffering and danger in proportion as his other functions and feelings are active and impressible, and tempt him to efforts which the straitened organs are unable to bear. It is on this account that occasional attacks of spasmodic asthma and pulmonary congestion are very apt to occur in connection with ossified bronchial tubes; and that painful and dangerous paroxysms of angina often supervene when the arteries and valves of the heart are in the same condition:—whilst the more completely or uniformly *petrified old man* remains comparatively free from similar affections so long as he is kept in a state of

vegetable or almost mineral quiescence. These considerations suggest important points of practical application.

Treatment of Degenerations.

547. It may readily be inferred from the preceding remarks, that if there are any measures which are capable of resisting the progress of degeneration of structures, they are such as tend to sustain the vitality of the frame, and to preserve the organic functions in equally balanced activity. Hygienic influences, such as pure air, regular exercise, friction of the surface, baths warm or cold, as the system can best bear them, and nutritious and carefully selected food (§ 60, 219), deserve the first mention. Of medicinal agents, those generally denominated tonics, may be of some little utility, such as preparations of iron, bark, arsenic, and the mineral acids; but, as in most cachectic states the secretions are commonly more or less defective, these medicines are not well borne unless they are combined with others, such as alterative aperients and salines, which possess the power of obviating the deficiency; the combination is presented in a convenient and attractive form, in the various chalybeate and saline mineral waters of the most frequented spas. These are the favourite resorts of persons of "worn out constitution," who are in truth more or less subjects of degenerative structural changes, and who find in the regular routine, and healthier habits, as well as in the remedial virtues of the waters and baths of these places, a degree of relief and a restoration of strength which they fail to obtain from medicinal treatment at home.

Partial degenerations are promoted, as we have seen, by a disordered state of the circulation of the part, commonly from congestion or inflammation in a low form; hence the treatment should comprise the attempt to remove or counteract such local derangement by the employment of gentle means, chiefly topical, that cannot compromise the constitutional powers of the patient. There are individual remedies which claim to be especially applicable to particular kinds of degeneration.

Fibrous and granular degenerations, as they are commonly partial, and result from continued or repeated inflammations, may be in some measure retarded by the less weakening forms of antiphlogistic remedies, as for instance the employment of counter-irritation, local bathing, and friction with stimulant liniments,

and the external and internal use of preparations of iodine, and the alkalies. These means are serviceable in restoring power to muscles injured by rheumatic and other kinds of inflammation, which tend to fibrous degeneration. Mercury is generally too weakening to be administered as an internal remedy, but it is sometimes useful when applied externally.

The peculiar chemical nature of fat, and its special relation to particular organs, the lungs and the liver, suggest to us means which may tend to prevent its accumulation in the system, and its substitution for the more highly animalized textures. The rigid exclusion of all fatty articles of diet, the moderated use of saccharine matter and fermented liquors, and the adoption of lean meats, bread, and succulent vegetables for food, conjoined with a due portion of salt and other condiments; the promotion of free circulation and respiration, by regular exercise in pure air; occasional bathing and friction to promote the action of the skin; and the regulation of the bowels, aided, if necessary, by medicines which augment the secretion of bile; such are the chief means by which the adipose cachexia is to be combatted. The tonic remedies recommended in degenerations in general, are also unquestionably of service here, particularly the various preparations of iron and quinine; and I have known several examples of temporary benefit resulting from their employment in cases which ultimately proved to include fatty degeneration of the heart. In some instances the nitric or nitromuriatic acid has been found advantageous; in others, ammonia; and one is tempted to attach some meaning to the peculiar composition of these agents—as being of an opposite nature to fat—the acids affording abundance of oxygen which may remove a part of the superfluous fat, and both these and ammonia supplying azote which may contribute to the formation of a more highly animalized plasma. The disposition which fatty material has, to assume the solid form in these degenerations, suggests that an advantage is likely to arise from the use of some solvent capable of liquefying the adipose concretions; and I know of no agent so likely to possess this quality as the liquid part of cod-liver oil, the power of which to remove deposits that abound in fat will shortly again come under notice.

Very little is known of any measures that are calculated to counteract the calcareous degeneration, further than such as have been already recommended with the general object of sustaining

vital energies, and preventing the nutrition of parts from being perverted by inflammatory or congestive disorder. Hydrochloric acid exerts a remarkable solvent power on salts of lime: in some cases mollities ossium has been supposed to have arisen from an excessive use of salt, but it is quite uncertain whether such a property would reach to the morbid deposition of phosphate of lime in textures. Some hints have been thrown out before, regarding the expediency of limiting the subjects of ossification to a restricted sphere of excitement and exertion (§ 546).

SECTION VI.

DEPOSITS IN OR UPON TEXTURES.

548. The term *deposits* is applied, in a pathological sense, to matters which result from an overflow of nutritive material beyond the amount that is necessary for the nutrition of the textures. The structural lesions hitherto considered are alterations of the textures themselves; deposits are new matters added to the textures. The basis of all morbid deposits is the fibrinous matter of the blood; in speaking of the products of inflammation (§ 450—3), we have described their varieties in relation to their plasticity or capability of organization. The same relation intimately affects the character of deposits, which take place independently of inflammation, as results of overflow and perversion of the material of reparative nutrition, which so may be either *euplastic, cacoplastic,* or *aplastic.* What has been said of these peculiarities of perverted nutrition when treating of inflammation, has anticipated the necessity of alluding to them in detail now, and it will therefore suffice to advert to the circumstances in which they arise independently of inflammation.

*Euplastic Deposits—Cicatrices.**

549. When a living part is wounded or injured, the breach may be repaired in four different ways:—1. By the "immediate union" of Dr. Macartney. 2. By the "union of adhesion" of Hunter, which is the same with the "healing by the first

* The following paragraphs have been rewritten by Dr. Mann.

intention." 3. By the "development of new tissue" from nucleated plasma; and 4. By "suppurative granulation." It was once a general opinion amongst pathologists, that inflammation is essential to the accomplishment of repair; but it is now known that the first three processes enumerated above are completed without the occurrence of inflammation, and that, indeed, they are interfered with and arrested when it supervenes. The fourth process, that by suppurative granulation, is intimately connected with inflammatory action, and therefore its consideration does not belong to this part of our subject, although incidental allusion to it cannot be avoided. The connexion of inflammation with healing operations seems to have been mainly designed for increasing the plasticity of the blood in such cases as are deficient in this quality, and in which, therefore, the simpler means would fail.

Considerable light has been thrown upon the nature of the reparative process by Mr. Paget,* and a very lucid and interesting resumé of his views is given by Dr. Carpenter.† A considerable portion of the following explanations is derived from these sources.

The first method of healing, that by immediate union, is the simplest and most desirable of all. To Dr. Macartney the merit is due of first pointing out how little inflammation has to do with this and analogous operations, and that in general the reparative powers are in *inverse proportion* to the tendency to, or presence of, inflammatory action. Immediate union mostly takes place in slight cuts, like those which are made in venesection, and in larger wounds under circumstances which prevent irritation or inflammation. There is no increased redness or swelling, and no obvious effusion of lymph. Parts that are placed in close contact, and without any intervening substance, simply grow together. As Dr. Macartney remarks, and as might be anticipated, "this process is the slowest of all, but this is of little consequence when it is remembered that it is unattended with pain or constitutional disturbance, and that it leaves behind the best description of cicatrix."‡ This was the method of union which John Hunter spoke of as being "by the first intention." He believed that it took place through the medium of blood intervening between the lips of the

* See Lectures on Nutrition, Med. Gaz., 1849.

† See Principles of Human Physiology, 4th ed., p. 572, and 3rd ed., p. 613.

‡ Dr. Macartney's Treatise on Inflammation, p. 178.

wound, and becoming subsequently organized into a living bond. But it is now well known that this kind of union only takes place when no blood remains between the opposite sides of the wound.

550. The "union by adhesion" of Hunter, (union by first intention of modern British surgeons,) commonly takes place in incised wounds, whose sides cannot be brought into perfect coaptation. The connection is here established by the effusion of lymph into the vacant space, and by its ultimate organization through vessels passing into its substance from both surfaces; this bond becomes an enduring cicatrix that is quite unlike the surrounding tissue. The mere fact of the effusion of plastic lymph to this slight extent is not deemed to indicate the presence of inflammation.* Whenever inflammation is accidentally set up, the bond fails to perform its task.† The only circumstance, under which the supervention of inflammation can be regarded as salutary, is when there is a deficient organizability in the lymph, in consequence of want of fibrin in the blood. It has been seen (§ 438) that inflammation augments the quantity of fibrin in the circulating fluid, and every surgeon knows that there are cases of general depression, in which wounds with pale flabby edges will not heal until a certain degree of inflammation has been induced.

551. The third process of repair takes place when wounds are too extensive to be healed either by "immediate union," or by a thin insinuated "layer of coagulable lymph." A mass of nucleated plasma is first formed, and then new tissues are developed out of

* The following observation made by myself long ago illustrates this process:—"I made a small pin-hole in the web of a frog's foot; the capillaries that were divided yielded no blood, and became obstructed; but the circulation continued, although sluggishly, in those adjoining, which were distant from the puncture the length of six or eight blood-discs. The next day, these vessels were no nearer; but the circulation through them was more active, and the hole was partly filled up. On the third day it was completely so, yet no moving blood could be seen nearer to the spot. On the fifth day the distribution of visible vessels was not altered, but the matter with which the hole was filled had contracted and become opaque, so that the adjoining vessels were drawn nearer together; the opacity prevented my seeing whether any passed through the cicatrix."—Gulstonian Lectures, Med. Gaz., July 30, 1841, p. 721.

† Although I admit that inflammation in its pronounced form is not essential to this mode of reparation, yet there seems to be a close approximation to it in the process. When a frog's web is cut or pricked, the vessels adjoining the wound are immediately obstructed by coagulated blood; but in a few seconds, those just beyond become enlarged, and receive an increased current, and it is this determination of blood towards vessels which are obstructed, which causes an increased transudation of the plasma of the blood (§ 419). If this do not amount to inflammation, it differs from it only in degree.

this. But, as Mr. Paget has shown, the "filling up" takes place very differently accordingly as the part is excluded from air, or exposed to it. In the first case the nucleated plasma is developed into fibrous texture almost without inflammation, and without constitutional irritation. In the second case it is developed into cells, of which those on the directly exposed surface degenerate into pus globules, and are cast off. Local inflammation then occurs to a considerable extent, and gives rise to constitutional disturbance, and a very serious drain upon the system is set up. It is a curious fact, that in cold-blooded animals the first bland form of this mode of healing is accomplished, even although the injured part is exposed to the air. Dr. Macartney has termed this proceeding the "modelling process," but it is really granulation effected under the most favourable conditions. Nature attempts to carry out this plan whenever an injury has been too extensive to admit of its being repaired by the "immediate" or the "adhesive" union. She does so by forming a scab, and so converting an exposed into a covered surface, whereby the irritating presence of the air is excluded, and the healing consequently effected without inflammation or irritation, as it could not otherwise be.

552. When an open wound is healed by "suppurative granulation," the exposed surface is first "glazed" over by a layer of coagulated fibrin and colourless corpuscles. A period of complete inaction then follows, which may last from one day to ten, in which there is only a slight oozing of serous fluid; this is what Mr. Paget calls the "brooding time," in which either good or evil is hatching. The commencement of reparative operations is marked by the restoration of the flow of blood to the injured part. The current is slower, but fuller than usual; more blood on the whole is thrown through the vessels, and plastic material is effused from them in consequence; this material is first formed into cells, but these in the deeper parts are developed into fibres, out of which the substance of the granulations is composed. But those on the surface degenerate into pus globules. The pus constitutes a sort of epithelial layer which protects the fibrous granulation mass beneath. In this new blood-vessels are formed by outgrowth from the neighbouring capillaries, which have become very large, and often even varicose. "The vessel first presents a slight dilatation in one, and coincidently in another point; as if its wall yielded a little near the edge or surface. The slight pouches thus formed

gradually extend as fluid canals or diverticula from the original vessel, still directing their course towards the edge or surface of the new material, and crowded with corpuscles which are pushed into them from the main stream. Still extending they converge; they meet; the partition wall that is at first formed by the meeting of their closed ends clears away, and a perfect arched tube is formed, through which the blood, diverging from the main or former stream, and there rejoining it, may be continuously propelled."* Sometimes the projecting pouch gives way soon after it has originated, and blood corpuscles escape into the organizing plasma. At first they lie clustered confusedly together, but soon they are gathered into the direction in which the new vessel should have been formed, and so "channel" out a way into the opposite capillary pouch. This variation of the process bears out Mr. Travers's remark, that the new capillary arch formed by outgrowth does not directly carry a stream of blood. Isolated corpuscles enter it, and oscillate backwards and forwards in it for some hours before any of them pass through it, so that the new channel cannot be regarded as only burrowed out by a file of corpuscles pushed in from behind, as some have maintained.†

Suppurative granulation differs from the granulation of closed wounds (the modelling process of Dr. Macartney), chiefly in the fact that a large number of the exudation corpuscles deposited, degenerate into pus globules in the one case, and that none of them are thus wasted in the other. But in the former case, the presence of inflammation causes an increased quantity of fibrin to be formed, so that abundant granulations are made, and the solution of continuity is filled up much more rapidly than when the same repair is effected by means of more perfectly developed structures in the absence of inflammation. Rapidly formed granulative substance almost entirely disappears, subsequently to the complete closing of the wound. Two opposite surfaces of firm granulation will sometimes grow together if kept in contact with slight pressure. There are thus, then, two principal forms which

* Paget's Lectures in Med. Gaz., July, 1849, p. 72.

† There is nothing in Mr. Travers's observations which controverts the inference, which is drawn from numerous other facts, that the motion of the corpuscles in these new channels is derived from the adjoining capillary vessels. The oscillatory movements are those of the pulsation of the heart, and are seen in many instances on the arterial side of obstructed capillaries. No current of blood, or file of red corpuscles can pass, until there is also a communication with the veins.—See note, p. 321.

materials effused to constitute new texture may assume: namely, the *fibrinous* and the *corpuscular*. In the former, the deposit resembles the firm coagulum of healthy blood, only that it is somewhat more distinctly fibrillated. In the latter, it is characterised by the absence of perfect coagulation, and the clot is replaced by an aggregation of cells resembling the corpuscles of the absorbent vessels and of the blood. The two forms are generally more or less mingled together, but in proportion as the fibrin predominates, the exudation substance is firm and plastic and organizable, and as the corpuscles are more abundant it tends to degeneration (cacoplastic or aplastic). Inflammation makes the one form still more adhesive, and the other it pushes into suppuration.

Under some circumstances the coagulated fibrin of the blood itself has been found to become vascular, and more or less organized. Clots of blood independently deposited in the blood-vessels have been rendered vascular, and coagula effused in the brain in apoplexy have been found penetrated by vessels. The colouring material of the blood does not, however, seem in any way to assist the process. Blood coagulated in or upon a wound falls off in a scab as soon as the wound is healed. Dr. W. T. Gairdner has lately made some observations that countenance the notion long since held, that blood and blood-vessels may be quite independently formed in effused substance, without any outgrowth from neighbouring capillaries. He adduces one case in which a false membrane had been made by the organization of a clot of blood, effused into the arachnoid cavity in consequence of an injury. It exhibited a large varicose blood-channel without any very definite wall, and smaller branching vessels with distinct parietes, and there were in the large channel blood corpuscles of all dimensions, the smaller being far more abundant than in ordinary blood. The appearance was that which a rudimentary forming vessel and young blood would have presented, and there was no organic communication with neighbouring parts.* Dr. Quain exhibited at the Pathological Society specimens of loose fibrin passed from the urethra, in which there were ramified channels closely resembling a network of blood-vessels.†

553. *Remedial Measures.*—There are certain influences by which the performance of the euplastic process may be aided; but these

* Edinburgh Monthly Journal, Oct. 1851, p. 392.

† Pathological Transactions, vol. iv. p. 205.

vary according to circumstances. In some states the object is to cause increased determination of blood to the injured parts, and to augment the plasticity of the circulating fluid, so as to ensure a sufficient effusion of organizable lymph for the work to be done. More often the great aim should be to prevent inflammation. All treatment should be directed to secure, if possible, the "immediate" or "adhesive" union, in preference to any other mode of repair, or if this cannot be effected, to induce the "modelling process," rather than suppurative granulation. In the case of large burns on the bodies of children, the one or the other of these being pursued by nature, often determines the alternative of life or death. There are three principal things to be done in attempting to prevent the supervention of the suppurative in the place of the non-inflammatory method of repair. These comprise—1, the exclusion of air; 2, the regulation of temperature; 3, the constant application of moisture. Dr. Macartney maintains that no other agent is so effectual as steam, first at high temperatures, and subsequently not so hot. Water dressing commonly answers exceedingly well in preventing inflammation. It operates by producing such a degree of cold as can diminish sensibility and vascular action,—and as Dr. Macartney thinks, can approximate the condition to that which is always present, in the reparative process of cold-blooded animals. Extreme cold would altogether arrest the operation of repair. Dr. Greenhow of Newcastle substitutes the "modelling process" for suppuration in cases of recent burns, by forming an artificial scab for them, by liquefied resinous ointment,—and he states that he can prevent suppuration even when large sloughs are thrown off. Constitutional treatment materially aids the adoption of judicious local measures. When inflammation threatens to run high, and convert the reparative process into a destructive and degrading one, it must be met by active antiphlogistic means. If there be a tendency to low-toned inflammation, and there is not sufficient determination or richness of blood to cause an effusion of lymph, or if the lymph be not sufficiently plastic and organizable, stimulants, and tonics, with nourishing diet, sometimes aided by the addition of cod-liver oil, are highly serviceable. The power of a pure invigorating atmosphere to render the healing process healthy is often very remarkably illustrated. Nitric acid is sometimes useful, both internally and externally, probably on account of its oxygenating properties (§ 216). When wounds are affected by congestion, rather than by determination of blood, and

the effused plasma is converted into loose and spongy or fungous masses which project from the general surface, astringent and styptic applications are often of very decided service.

For further details on this subject, reference must be made to works on surgery.

Cacoplastic and aplastic deposits.

554. Under various circumstances which have been alluded to in the preceding remarks, wounds or ulcers may be repaired by lymph which is *cacoplastic* or defective in organizability; the cicatrix resulting from such imperfect repair is then lower in the scale of vitality than the texture in which it is produced. Thus in the skin, a tough, hard, opaque white fibro-cellular structure constitutes the cicatrix: the seams formed on the healing of scrofulous sores sometimes exhibit this character; the blood, in this case, not supplying a good plastic material. Sometimes the cause of degraded organization seems to be in the nature of the wound, or in some modification of the vessels of the part, or of the exudation from them, as in the scars which result from burns and scalds, and from certain kinds of poisoned wounds. In these cases, the cicatrix is dense and thick, and tends to further contraction, subsequently to its first formation, and this causes a puckering of the parts, and often great distortion of the integuments. Deposits similar to these cicatrices have been noticed in internal parts after chronic and scrofulous inflammation, (§ 479, 485,) and after congestion (§ 311); the dense fibro-cellular and fibro-cartilaginous formations that occur on and under serous membranes and in cellular textures are of this kind; and so also are the indurated interstitial structure which characterizes cirrhosis,* and granular degeneration of the liver and kidneys, as well as certain scars and consolidations very commonly met with in the lungs. The opaque, tough thickening of the valves of the heart, occasionally attended by corrugation, contraction, and rupture, and the similar change which affects the coats of arteries, appear to belong to the same class.

The structure of these deposits deserves to be more fully

* The term cirrhosis (from the obsolete Greek word, κιρρός, *yellow*,) was first applied by Laennec to the contractile disease of the liver; because the interstitial deposit which causes the contraction is often yellow from being stained with bile. The term is therefore obviously inapplicable to contractile deposits in the lung and other parts; to which the name has nevertheless been applied. The epithets, granular or contractile deposit, are more generally accurate as designations of these forms of cacoplastic product.

investigated. They appear to be more or less organized, being composed of irregular cells and nucleated fibres, imbedded in granular or amorphous solid matter in various proportions (§ 424). Their organization, however, differs much in degree, some being vascular, and some not; but they are all inferior in this sense to the structure with which they are connected, and to the euplastic deposits above described. Although rarely occurring in great abundance in any organ or structure, except in consequence of some hyperæmia of the part, yet in a small extent cacoplastic deposits are to be met with in most subjects at all advanced in life, more particularly in such as have long suffered from ill health. The opaque thickening of the membranes investing the liver, spleen, lungs, heart, and brain, often arborescent in arrangement from its accompanying the course of the blood-vessels—the coarse and irregular granular appearance exhibited in limited patches of the liver and kidneys, especially at their most depending portions, in which some of the granules are commonly adherent to the capsule of the viscus when it is torn off—the partial consolidations of the lungs, particularly near their apex—the opaque spots on the covering and lining membranes of the heart and arteries—are all specimens of cacoplastic deposits resulting from age and disease; and the more the nutrient function has been degraded in the individual, the more abundant these deposits are found. Generally, however, they attack one organ in particular, in consequence of previous disease having predisposed it to suffer (§ 31, 22). Thus if a person has injured the function or structure of the liver or kidneys, by habits of intemperance, or in any other way, the injured organ is the first to suffer, and when, in the lapse of time, age begins to tell upon the nutritive function, it then becomes the subject of contractile or granular and fatty degeneration; and this may destroy life by arresting circulation and excretion, &c. (§ 170, 311) before other organs are much affected: hence the occurrence of dropsy, jaundice, albuminuria, &c.

555. But there is another more general variety of cacoplastic deposit, which takes place when textural nutrition is degraded still further than in the preceding examples; this is the *semi-transparent, miliary, grey, and tough yellow forms of tubercle.* Instead of (with Laennec) classing tubercle under the vague term of "accidental productions," or (with Carswell) as a "secretion *sui generis*," I have for many years been induced to refer it to a

degraded condition of the nutritive material from which old textures are renewed, and new ones formed; and to hold that in its origin it differs from the normal plasma or coagulable lymph, not in *kind*, but in *degree*, of vitality and capacity of organization.* These views have received almost demonstrative confirmation from the microscopic researches of Mr. Gulliver and others, which have detected in tubercle the materials of lymph, in a degenerated and confused state, the cells being few, irregular, and often shrivelled, with imperfect nuclei, which seem to be incapable of further development; no fibres being perceptible, and the main substance being composed of granular or amorphous matter.† Every gradation may

* A somewhat similar opinion, but less definitely expressed, has been entertained by Dr. Alison, and formerly by M. Andral; but these pathologists seem originally to have regarded tubercle as being chiefly the product of a modified form of inflammation.

† "Corpuscles more or less globular or oval are seen in tubercles; but the granular matter preponderates as the tubercular mass increases. Cells may be recognised in the miliary tubercles; but as they increase in size, the well-marked and complete cells disappear. Tubercles appear to differ essentially from the plastic exudations, inasmuch as the cells of the latter not only grow into a higher organization, but increase in number towards the centre; in other words, plastic matter has an inherent power of multiplying and evolving organic germs. But tubercle has no such power; for it would appear that its primitive cells can only retrograde and degenerate." (*Gulliver's Appendix to Gerber's Anatomy*, p. 87.)—"If a tubercle, or even the tissue of the lung near it, be slightly compressed between two slips of glass with a drop of water, it will crumble down and break to pieces, the fluid being at the same time quite white or milky. This white appearance is attributable to a great number of minute objects, the assemblage of which constitutes the substance of the tubercle. They consist for the most part of molecules, granules, and granulated corpuscles, of various sizes, of aggregated granules without any tunic, and of collapsed tunics without any granules. These objects are mingled with a great many shapeless flakes and filaments, which are no doubt fragments of the membrane of the air-cells, and of the minute blood-vessels, which, when involved in a tubercle, become so extremely brittle, that they must necessarily form a considerable proportion of the objects occupying the field of the microscope. The granulated corpuscles of a tubercle are sometimes very large, ($\frac{1}{800}$ or $\frac{1}{1000}$ of an inch); and the molecules and granules, which are very conspicuous, may frequently be seen on the point of escaping from them. . . . The semi-transparent forms of tubercle and tubercular infiltrations owe their peculiarity to a great relative amount of granulated vesicles, (*cells*, Gulliver); whereas the opaque white forms of tubercle are attributable to great numbers of isolated granules." —(*Mr. Addison's "Experimental and Practical Researches, &c.;" Trans. Provincial Med. and Surg. Association*, 1843, p. 287, 8.) Rokitansky describes tubercle to consist of a more or less pellucid base, with elementary granules of various magnitudes, nucleus formations in various phases, and scanty nucleated cells. "The nuclei and cells are often to a great extent misshapen, disorderly, jagged, angular, bulging, dumb-bell-shaped, rudimental, stunted." (Pathol. Anat., Sydenham Soc. Trans., v. i. p. 295.)—Rokitansky views tubercle in the light of an altered fibrin; and he considers miliary tubercles to correspond with the fibrinous, and the yellow tubercle with the croupous variety of lymph.

Very similar appearances have been described by other writers; and although some

be found between euplastic and aplastic deposits; the cells and fibres which are the representatives of organization diminishing in number and completeness, and the material becoming more granular, amorphous, or more abundant in fat globules, in proportion as the deposit is degraded, until, in opaque, crude, or yellow tubercle, it is altogether aplastic, consisting of a mere aggregation of granules and fat globules, interspersed with the mere traces or remains of cells.

I consider that the more solid forms of tubercle are entitled to rank among cacoplastic deposits; because, although destitute of vascularity, they seem to possess a kind of structure, like that of the lower kinds of fibro-cartilage and granular deposit. In the semi-transparent, grey, tough yellow, and miliary varieties, vestiges of cells and fibres are commonly seen. The affinity of these with granular degeneration (§ 544) and fibrous deposits is shewn by their commonly occurring in the same subjects, and by their frequently exhibiting the same tendency to contraction. In a very large majority of cases of chronic granular disease of the kidneys or liver, there are found more or less traces of tubercle in the lungs, the chief seat of its deposition; and in very few instances of chronic phthisis have I failed to find some degree of granular disease in the liver or kidneys. In acute phthisis and in acute granular disease, local causes accelerate the degenerative change to a destructive extent in one organ, before there is time for others to become affected.

556. We now proceed to trace the history of cacoplastic deposits by a few examples. The dense false membranes formed on the surface of serous membranes may be often seen to be surrounded by a radiated wrinkling or puckering of the adjoining parts, indicat-

have adhered to the notion of some peculiar form of cell or corpuscle as characterizing tubercle, the general inference is that tubercle is an imperfectly organized matter, without anything specific or distinctive in its constituent particles. One of the most recent authors, M. Mandl, describes true tubercle as an amorphous matter, consisting of mere granules or molecules, and subject as unorganized albumen to fatty transformation. (*Archives Gen. de Med.*, 1855.)

These various observations supply microscopic evidence in favour of views regarding the nature of tubercle, which I have long held and taught, and to which I was led by an attentive examination of the common characters and changes of lymph, pus, and tubercle. A brief notice of these views may be found in the four editions of my little work on the "Pathology and Diagnosis of Diseases of the Chest," 1828-40; in my "Lectures on Diseases of the Chest," published in the "Medical Gazette," of 1837—8; and in the "Library of Practical Medicine," vol. iii. 1840. All these works were published long before any of the above microscopical examinations were made.

ing that the abnormal substance has shrunk in size subsequently to its being first laid down. A similar contraction is noticed in the deposits that occur on and under the lining membrane of the heart and its valves, and here it causes a serious disturbance of the mechanism. The narrowing of the chest in some cases of pleurisy is, in part, dependent on the same property of cacoplastic deposits. This tendency of false membranes to contract was long since pointed out by Dr. Hodgkin and Laennec; and the fact has been subsequently applied by Dr. Carswell to explain the diminished size of the liver in cirrhosis, which he considers to be due to a deposition in the intravascular filamentous texture prolonged from the capsule of Glisson. I do not myself think that the contractile deposit in cirrhosis is exclusively confined to one texture, but believe that it is generally exuded from the distended blood-vessels. False membranes, which exhibit the same contractile character, are sometimes found on the free surface of serous membranes, and especially along the course of the vessels (veins as well as arteries); and depressions caused by atrophy of the substance of the organ beneath these deposits are sometimes seen in the liver and lung. There can be little doubt that these deposits originate in a fibrinous material exuded from the vessels in certain pathological states, (congestion, chronic inflammation, and malnutrition,) and forming a dense structure of low vitality, which tends, by its subsequent contraction, to constrict and compress the subjacent parts, and so more or less to interfere with the passage of blood through them, and consequently to derange their nutrition and vital operations. The same tendency is evinced in the higher (less aplastic) forms of tuberculous disease. Miliary or granular tubercles in the lungs, when in considerable numbers, and not soon softening, cause a contraction of the substance of the organ, chiefly at the upper part, and a corresponding collapse in this portion of the chest. I have met with many cases, in which a sinking in of the infraclavian region has taken place before any symptoms of softening or excavation have occurred; indeed this is a very common sign of the presence of tubercles which remain long stationary. The still greater amount of structural collapse, in the advanced stages of tuberculous lesions, although partly dependent on other causes, is also still in some degree connected with the contraction of cacoplastic deposits in the lungs and pleura. In the peritoneum agglutinated tubercles often cause considerable contraction; I

have seen the omentum puckered up by them into a knotty mass.

The microscopic examination of cacoplastic deposits at different stages of their formation, throws considerable light upon the true nature of this process. When recent, the effused matter consists of fibres with a great quantity of granular, and more or less of amorphous substance, with or without an admixture of cells. At a later period, and after it has contracted, it is much more tough, and it is then found to be more distinctly fibrous, much of the granular and amorphous matter having disappeared. Old contractile adhesions and cicatrices are still denser, and when examined by the microscope are seen to consist almost entirely of closely interwoven fibres, differing from those of fibro-cartilaginous tissue only in being less regular and distinct. Grey or granular tubercles wither and become more tough or horny ("cornify"—*Rokitansky*) and thus remain quiescent. It appears therefore that it is by the partial absorption of the granular and amorphous portion of the deposit and by the closer approximation of the fibrous, or more organized constituent, that the condensation takes place. Hence it is, that the structure so contracted is subsequently less liable to the further degeneration to which cacoplastic deposits are prone. Certain it is, that of different portions of cacoplastic deposit in the lungs and elsewhere, those that are contracted remain unchanged, whilst the rest pass into the aplastic state of opaque and softened tubercle. The contractile process seems, therefore, to raise the deposit to a higher standard, so that although still inferior in vitality to the adjoining textures, it gets to be tolerated by them, so to speak. But this very change may seriously injure the textures of organs, by contracting and compressing their vessels, and interfering with their nutrition and other functions, and in this respect therefore it may be compared with the highest, or most animalized variety of degeneration, the fibrous, which has already been described (§ 543). It is in this way that the contractile diseases of the liver and kidneys gradually infringe on the circulation and secretion of these organs, and eventually prove fatal (§ 249, 375). The contraction which takes place near the apices and roots of the lungs, in the more limited and therefore more chronic varieties of pulmonary tuberculous disease, often lays the foundation of emphysema of the organ and habitual asthma. I have notes of a large number of cases illustrative of this fact:

but such details belong rather to special than to general pathology, and are reserved for another work. It is a similar change in the deposit formed under the mucous membranes of the alimentary and urinary passages that constitutes the strictures, which cause so much distress and disorder in these canals.

557. Having described the less degraded and degenerating form of cacoplastic deposits, it now remains to notice the variety which is of a lower character, and which tends to become aplastic. This includes all the commoner forms of tubercle. In the granular, miliary grey, or drab-coloured tubercles of serous membranes and of the parenchymata of organs, there is found a dense homogeneous solid, closely resembling some of the cacoplastic deposits which have just been described. The resemblance, and even identity of these, may often be very well traced out in chronic or subacute arachnitis, peritonitis, and pleuritis; portions of the affected membrane are covered with diffused patches of semi-opaque deposit, which no one would hesitate to call false membrane; whilst in other parts separate granules of precisely the same deposit exhibit all the characters of granular or miliary tubercle. But (it may be asked) how comes it here to assume the granular form? The answer to this question will be found in the observations previously made, on the products of inflammation (§ 449), where it was pointed out that the effusion of lymph on an inflamed membrane is at first granular, and that it would continue to be so, if it were not drawn or spread into threads or films by the friction or pressure of the surfaces where it is poured out; several examples were there cited, to show that in the absence of such friction or pressure, the granular appearance is preserved even in acute inflammation. In scrofulous and chronic inflammation, the matter effused is from the first less ductile and more consistent, and the granular condition consequently more generally prevails and remains even in spite of pressure and friction: and it is admitted, that the product of chronic inflammation of the peritoneum and of the arachnoid membrane is always more or less granular. In acute inflammation in tuberculous subjects, recent lymph is commonly studded with opaque granules, which subsequently assume the character of tubercles.

But tubercular deposit is not always preceded by inflammation. In many cases, tubercles are found so extensively disseminated through different textures, after few or no symptoms of inflammation, that

it is quite impossible to regard them otherwise than as the result of modified textural nutrition. The cell-germs by which the organized fabric is renewed, are imperfect at particular points; granular or amorphous matter is deposited at each of these from the plasma, and concretes without fibres or regular cells being developed in it; and a granulation then appears, and gradually hardens. Where a granule has once been formed, it becomes a nucleus for further concretion: a new habit or mode of nourishment is established at the spot; or, to speak less figuratively, the cacoplastic matter present in the blood plasma is drawn thither by a process similar to that by which fat attracts fat, or bone attracts osseous particles; perhaps this process is not altogether different from crystallization, a supposition strengthened by the fact that in Mr. Gulliver's experiments a deposit of new osseous matter occurred in dead bone which had been placed within a living inflamed one. (Med. Chir. Trans., vol. xxi.) But however this may be, the result is, that the granular tubercle grows until it attains the size of a millet-seed, a hemp seed, or rarely even that of a small cherry-stone; if subjected to pressure it slightly spreads or flattens into various shapes.

The microscopic character of these miliary or granular tubercles is the abundant presence of minute and often irregular granules, and the comparative absence of fibres and cells, of which mere traces only can be seen, at least in the older specimens. The granules are aggregated together by an amorphous material, the solidity of which gives hardness and some translucency to the mass; acetic acid and alkalies dissolve or make transparent this cement, loosen the granules, and render them distinct. In chemical nature granular tubercle is albuminous with a little fat in its composition; the latter in minute molecules here and there, occupying chiefly the centre of the granules; the albumen probably constituting the amorphous cement alluded to above. In all this there is a close analogy to the granular degeneration of textures (§ 544), of which doubtless tubercular deposition is but a kind of exaggeration.

Miliary tubercles exhibit a considerable variety in size and consistence according to their age. When recently formed, they are plump, and although feeling harder than the surrounding texture, yet they can be crushed with firm pressure between the fingers. But in lapse of time they contract in size and become

tougher, so that no pressure can crush them. This change, termed by Rokitansky, *cornefaction,* is in the lung accompanied by a darkening of colour, so that old tubercles are often quite black. This is usually an indication of the tubercle having become quiescent or obsolete, and having little tendency to degeneration into the yellow form.

558. Tubercles rarely occur in numbers or spread much without exhibiting another change of appearance. They lose their semi-transparency, and become of an opaque or dead pale-yellow hue, like the colour of raw potato or parsnip. This marks the transformation to crude yellow tubercle first described by Laennec; and this is the result of a further degradation or degeneration of the deposit. The few fibres and cells which are to be detected in grey tubercle are no longer distinguishable here, the interstitial hyaline or amorphous solid is greatly diminished, oil globules appear in its stead, and the mass becomes proportionally less coherent and more granular, and is now indeed quite *aplastic.* Generally the change begins in the centre of the mass; apparently because, there being no permeating vessels, the centre is the furthest removed from the vivifying influence of the blood. The cornea, and other non-vascular textures, occasionally become opaque in a similar way in consequence of deficient supply of sustaining nutriment in the plasma, and may indeed entirely lose their organization (§ 269). A parallel form of degradation is that which is observed in the degeneration of fibrous and cellular tissues into granular matter, recently pointed out as resulting from mal-nutrition (§ 544). But not only will deficient supply of healthy plasma promote the transformation of tubercle from grey to opaque; an undue flow or accumulation of blood, produced by congestion or inflammation in the neighbourhood, will also accelerate the change, just as the same occurrence hastens the disintegration of lymph and of compressed textures, the conversion of the plastic into the aplastic, through the increased warmth and afflux of fluids exalting chemical affinities in a material which has none of that vital power of resistance by which living tissues maintain their integrity.

559. But tubercle is frequently deposited at first in this yellow, opaque state; this circumstance then indicates the still more degraded condition of the nutritive function; the most extensive forms of tuberculous disease commonly present most of this aplastic matter. In rapid phthisis, whether resulting from acute

inflammation in a scrofulous subject, or from the excessive prevalence of a scrofulous diathesis (cacoplastic matter in the blood) yellow tubercle generally forms a large portion of the deposit; and it is in these cases that its resemblance to, and connexion with, coagulable lymph, may be best seen.* Yellow tubercle is rarely so hard or so tough as the grey or semi-transparent kind; and in such cases of rapid deposit as those just mentioned, it is often very much softer and more friable. Now, this state marks the commencement of a change to which the lowest forms of tubercle particularly tend—that, namely, of *maturation* and *softening* into a substance of cheesy consistence. The conversion of grey into opaque tubercle, and the subsequent further softening of the latter, seem to be the converse of the contractile process to which the higher class of cacoplastic deposits are prone: in that (the contractile process) the deposit becomes more dense and organized: in this (opaque change and softening), it becomes less dense, and loses the little trace of structure which it possessed; it degenerates into an amorphous granular mass; and being lifeless it is no longer nourished; but its granules lose their cohesion, and become disintegrated by spontaneous softening, aided by the chemical action of the adjoining fluids. Mr. Gulliver long ago noticed that there is a remarkable increase of fat globules in softened tubercle, and this has been confirmed by many subsequent observers. In fact, from the time that tubercle begins to assume the opaque form, oil globules appear to increase in it, and this goes on until it is either softened and eliminated, or has undergone the petrifactive change to be described hereafter. The conversion of grey into yellow tubercle, and the maturation and softening of the latter, appear therefore to be dependent on a fatty degeneration, resembling that which takes place in fibrinous deposits (§ 454), and in nourished textures (§ 545).

The increase of fatty particles in old pus (§ 460), in the atheroma of arteries, and in the chronic inflammatory deposits and gangrene of the lungs, was adduced in the former editions to show, that fat is sometimes a debris of animal matter, as it is when flesh out of the body is converted into adipocire (§ 543). The detection, by

* The affinity between lymph and tubercle was recognised by some of the older writers; and after it had been kept out of view by the too exclusive adoption of the opinions of Bayle and Laennec, it was again pointed out by Dr. Alison. (Trans. of Medico-Chirurg. Soc. of Edin., vols. i. and iii.)

Dr. Davy, of oleine and margarine in opaque exudation corpuscles in the lungs (§ 543) and the observation, by myself and others, of numerous fat globules in deposits in the kidneys and spleen, and in the vegetations on the valves of the heart, were formerly adduced to show a tendency to the production of fat in all degenerated plasmata; and fatty degeneration in the minute arteries of the brain, in the kidneys, and in other organs, has long since been described by Mr. Gulliver:* but the most complete confirmation of this view is to be found in the researches of Dr. R. Quain, before alluded to (§ 545), and in several subsequent contributions on fatty degeneration, especially in the discovery by Kilian and Rainey, of fatty transformation of the uterus after parturition. In many instances the fatty matter presents itself in a solid form, (either crystallized or in granules,) rather than as distinct oil globules; and this fact suggests that a change has occurred in the quality, as well as in the quantity, of the fat that is contained in the deposits, and that this probably prevents its absorption. These considerations which have before been noticed in the paragraph devoted to fatty degeneration (§ 545), prove that morbid deposits are amenable to the law of fatty or hydrocarbonaceous transformation in common with natural structures; and that they are indeed more liable to this sinking in the scale of organic composition in consequence of their low vitality, and of their extravascular position placing them beyond the reach of the decarbonizing influence of the circulating blood. As the change is in a great measure spontaneous, and as it is promoted by moderate moisture, it increases with the age of the tubercle, within certain limits, beyond which the mineral transformation or petrifaction ensues. But if the deposit be still further deprived of the preserving influence of the living textures, whilst it is kept moist by the exhalation from the surrounding congested vessels, a softening and decomposition more rapid and offensive than that of fatty degeneration may take place; and in extreme cases verges upon gangrene. Thus when many tubercles soften early and largely, they do so by a decomposition which is more rapidly destructive; and this, by generating matter that is offensive to the adjoining textures and to the whole frame, causes the local and constitutional irritation, so strongly marked in acute cases of a phthisical kind.

560. In these successive changes of tuberculous matter, as well

* Edinburgh Med. and Surgical Journal, 1843; and Med. Chir. Trans., 1843.

as in its original deposition, the adjacent living parts have an intimate concern. A miliary tubercle may cause irritation and obstruction to the contiguous textures from its first formation. The extent to which it does this depends on the natural or acquired vascularity and excitability of the part, the character of its function, and the precise situation and size of the tuberculous deposit. Thus, there is more tendency to mischief and rapid change in vascular and parenchymatous textures than in serous membranes. When the irritation is very slight, it may merely lead to so much determination of blood as will promote the growth of the grey tubercle. When it is more severe, it may cause the conversion of grey into yellow tubercle, its further increase in this form, and its softening. If the irritation be still greater, inflammation is excited around the deposit; traces of its existence are often seen after death in the form of an areola of vascular redness; the products of this inflammation (pus, lymph, mucus, and serum,) tend to hasten the softening of the tubercle, and the evacuation of its substance, mingled with their own, by ulceration through adjoining open surfaces. Or, being more solid and plastic, they lead to the formation of consolidations, or false membranes, around the tubercle, and so to the limitation of the irritating influence. Thus although, as just stated, the opacity, maturation, and softening of tubercle depend essentially on progressive degeneration and destruction, these changes are nevertheless hastened and modified by the afflux of blood to the neighbouring parts.

561. In the absence of the circumstances specified above, as tending to promote the increase or the further change of tubercle, it may remain comparatively harmless for months, and even for years, subsequently to its first deposition; but then it often exhibits a peculiar transformation which may be considered to be more spontaneous and of a chemical nature. This is altogether different from the change of the less cacoplastic forms by contraction, already noticed as implying an elevation of the deposit to the condition of a fibrous tissue, nourished and preserved as a living part. In the lungs, consolidations commonly remain for a long time without any contraction, and become deeply blackened by an accumulation of the peculiar colouring matter of the pulmonary texture. But yellow and softened tubercle, if not evacuated, in time becomes replaced by a plastery or putty-like matter, composed chiefly of phosphate and carbonate of lime, and often containing solid concretions, con-

sisting entirely of such earthy matter. This petrifactive transformation recals to mind what has been spoken of in relation to cacoplastic depositions in the coats of arteries, and on serous membranes (§ 544, 553), and as constituting the structural alteration that is erroneously called ossification; and it establishes the fourth and last parallel which connects tubercular change with the degenerations that kindred textures undergo from the influence of age or disease;—that namely, of osseous or mineral transformation. The calcareous conversion of tubercle can be explained only on the supposition that organic matter is absorbed, and the earthy salt deposited in its place. This is exactly what happens in the true petrifaction of organized bodies, the silica or calcareous substance being substituted molecule for molecule for the organic principles: so that when there is nothing remaining but the stone, it is moulded in the original form of the organized body. This is very important, inasmuch as it proves that the animal matter of tubercles may be absorbed. The occasional absorption of tuberculous matter is also illustrated by its accumulation in the bronchial and mesenteric glands, which sometimes contain it when the lungs and the intestines present only cicatrices, with some cretaceous matter in them. Tubercle very commonly exhibits the petrifactive change in the bronchial glands too; the concretions often found in these situations may generally be ascribed to this source.

562. The circumstances which degrade the material of nutrition, and lead to the deposition of cacoplastic and aplastic matter, may be either local or general. Of the local causes, congestion and the lowest and most chronic forms of inflammation have been already mentioned as capable of determining cacoplastic deposits; but even in these cases it is probable that the general cause also more or less operates—that is, a degraded state of the plasma of the blood. Congestions and chronic inflammations certainly do cause cacoplastic deposits; but then, such congestions and chronic inflammations do not easily occur in healthy subjects; and the want of health implies that there is some fault in the blood plasma. Practically, it is, however, of very great importance that the local as well as the general influence should be kept in view, for the former is often more tractable than the latter, and by obviating, it slighter degrees of disorder of the plasma may be prevented from doing mischief. The general cause, when present in high degree, leads nevertheless to cacoplastic and aplastic deposition, as a mere modi-

fication of ordinary textural nutrition, and independently of the occurrence of inflammation, or even of congestion. It then constitutes the chief element of the scrofulous diathesis or tuberculous cachexia, and as has been before stated, the most obvious physical condition in this is defect of the red corpuscles and excess of the fibrin in the blood (§ 185, 211). In this condition of the circulating fluid there is an increased disposition to deposit, and often an abundance of the plastic or crude nutritive material, but there is also an imperfect vitality or organizability of this material, so that when deposited, instead of being completely assimilated to the textures, it forms the degenerated structures or mere granular or amorphous substances which have been described. But when this condition of the nutritive fluid is present, such low deposits must be promoted by all varieties of hyperæmia, and they must also abound most in organs which receive the largest amount of blood. Where most blood goes, there too the most of its depravity must be carried. Hence, the peculiarly pernicious effect of inflammation of internal organs, and especially of the lungs, in scrofulous subjects. Even acute inflammation is then too often unable to raise the nutritive material to that plastic standard in which it can be organized or absorbed, or to place it in that condition in which it can be subjected to the process of complete suppuration whereby it may be speedily excreted; and the matter thrown out is merely cacoplastic or curdy lymph, remarkable for its opacity and want of cohesion, or it is a caseous kind of pus, inorganizable, inert, irremovable by absorption, and permanently obstructing or compressing the structures in which it accumulates, until it gradually excites an irregular destructive suppuration or ulceration in them, forming vomicæ, or imperfect abscesses pervading their substance, and destitute of walls capable of carrying on the healing process: under the depressing and irritating influence of the morbid matter decaying and becoming decomposed, the body wastes and is harassed with hectic fever, nightsweats, and colliquative diarrhœa. So likewise fevers, by causing congestions in organs, may lead to the production of a *crop* of these deposits, and so ultimately to tuberculous disease.

563. The lungs and bronchial glands are far more commonly the seat of tubercles than any other parts; when found elsewhere, they are nearly always yet more abundantly present, and in more advanced stages, in these parts. But the situation of the more marked

development of tuberculous disease varies also with the age of the subject. Thus, M. Papavoine found that in children yellow tubercle occurs most frequently and abundantly in the cervical and mesenteric glands; next in the spleen, pleura, liver, and small intestines; then in the large intestines and peritoneum; and more rarely in other parts. In 350 consumptive cases (chiefly adult) examined by M. Louis, there were tubercles in the small intestines in one-third of the whole; in the mesenteric glands, in one-fourth; in the large intestines, in a ninth; in the cervical glands, in a tenth; in the lumbar glands in a twelfth; in the spleen in a fourteenth; and in other organs in smaller proportions.

The greater liability of the lungs to tuberculous deposits, has been ascribed by some writers to the finer size of their capillary vessels, which act as filters to the blood, arresting the tuberculous matter already in a solid state in that fluid. But this view is untenable for several reasons. 1. If the fine size of capillaries were the chief cause of the deposit, it should also take place abundantly in muscle, the capillaries of which tissue are even finer than those of the lungs. 2. If the solid matter were first arrested mechanically in consequence of its obstructing small vessels, the appearance of vascular distension would be obvious from the first, and the deposit would exhibit somewhat of a capilliform shape; this however is not the case. 3. The deposit has been distinctly traced by Messrs. Gulliver, Addison, Rainey, and others to be extravascular, sometimes lying on the surface of the air-cells, and sometimes in or under the membrane composing them.* I think it highly probable that tuberculous matter may form within the blood-vessels themselves. I have repeatedly found matter presenting all the external characters of yellow tubercle in the blood-

* Pulmonary tubercle has been described by Van der Kolk, Addison, and R. Hall, to originate in a diseased state of the epithelium of the air-cells of the lungs. But the very existence of this epithelium is denied by Mr. Rainey, a very accurate observer; and it seems probable that the appearances of enlarged and fatty epithelium-cells, are derived from the adjoining bronchial tubes. Dr. R. Hall (*Brit. and For. Med. Chir. Rev.*, Oct., 1855), like Gruby, Lebert, and others, ascribes to tubercles a peculiar form of cells, but my own observations coincide with those of Gulliver, Rokitansky, and Mandl, which discovered none but abortive, withered, or mis-shapen cells, with abundant granular or hyaline matter, in simple tubercle. When it softens, there is more appearance of cells, both from portions of granular matter becoming enveloped, and from the addition of inflammatory exudation cells. In all these observations it should not be forgotten how readily granules, oil-globules, and even blood-corpuscles acquire an extemporaneous investiture of an albuminous film, which gives them at once the aspect of cells.

vessels of tuberculous lungs.* In fact, wherever fibrin can coagulate, there its degraded form, tubercle, may occur; and I cannot but refer in support of this view to the opaque softening of clots of fibrin in coagula in the heart and great blood-vessels. Formerly, this softened fibrin was mistaken for pus; but Mr. Gulliver has pointed out this error by showing that it had no characteristic cells. Its aspect and microscopic composition in reality differ in no essential particular from those of soft tubercle. This leads me to infer that the fibrin of blood when stagnant within vessels, or extravasated from them, may, in tuberculous subjects, sometimes change into aplastic tubercle. But the reasons already advanced make it obvious that in its early form tubercle is an extravascular deposit, resulting from modifications of the ordinary nutritive secretion.

I believe that several circumstances contribute to render the lungs especially liable to tuberculous deposit. 1. Their great vascularity and the large quantity of blood that passes through them, makes them, in a proportionally large amount, partake of any disorder in the condition of this fluid. 2. Their functions being in a degree connected with the formation of fibrin, for that principle is more abundant in arterial than in venous blood (§ 194). 3. The softness and yielding nature of their texture, which permits effusion to take place in it more readily than it can in denser parts. 4. Their exposure to the irritations of cold and other influences entering by the air-tubes, and to derangements operating through the medium of the circulation, renders them particularly obnoxious to such disturbance as is apt to give rise to the first deposition. In hot climates, cacoplastic diseases affect the liver and other abdominal viscera more than the lungs; the same persons there suffering from chronic liver disease and dysentery, who, in a cold climate would fall victims to phthisis.†

* Rokitansky mentions the occurrence, in the blood-vessels, of coagula of a tuberculous nature.—*Path. Anatomy, Syd. Soc. Trans.*, vol. i. p. 305.

† Mr. Simon and Mr. Ancell consider the tubercular diathesis to be due to deranged development of the proteinaceous constituents of the blood, whereby something is solidified, which should remain fluid. This, however, Mr. Simon attributes to the *oxydation* of the proteinaceous principle, a process very apt to be effected in the glands where lymph is brought into contact with arterial blood, and in the lungs where it is mingled with the oxygen of the atmosphere. Rokitansky maintains that venosity of blood is opposed to the development of tubercle. On the other hand, in Dr. T. K. Chambers's examination of 2500 cases recorded in the *post-mortem* books of St. George's Hospital, the liability to tuberculoses seemed to be in proportion to the degree of venosity in the part. This

564. As it has been seen (§ 562) that the cacoplastic condition of the blood of tuberculous or scrofulous subjects is connected with diminution of the red corpuscles and a preponderance of fibrin, so it may be stated that whatever tends to effect these changes is very apt to induce tubercle. Insufficient food, want of pure dry air, of warmth, and of light, long-continued mental depression, aggravated and prolonged disorder of the digestive organs, insufficient excretion (§ 249), and the occurrence of severe fevers and other analogous complaints, are acknowledged causes of both the general, and local development of tuberculous disease. Excessive evacuations of blood, or of the more animalized secretions, and severe courses of mercury, also predispose to phthisis, and most probably operate mainly by diminishing the quantity of the red corpuscles, and by injuring the quality of the plasma. The cessation of growth, the termination of pregnancy, the stoppage of habitual discharges, especially if they be purulent, and the amputation of a limb, are all circumstances well known to favour the development of tubercle, and they may be supposed to act chiefly by increasing the proportion of fibrin in the blood, when there is not a sufficiency of red corpuscles and of vital power, which is represented by them, (§ 183) to secure a due amount of elaboration for the higher purposes of life.

565. The *treatment* of cacoplastic and aplastic deposits, and of the conditions which lead to them, involves a vast amount of detail when all the circumstances relating to kind, situation, extent, and other occasional peculiarities are taken into account. It does not accord with the scope of this work to enter upon the consideration of these details; but a sketch of the rational principles of treatment, based on the statements and explanations already offered, will not be out of place in its pages. It will be my object that this sketch should particularize such practical measures as have the fullest sanction of experience.

should indicate that the great flux of venous blood to the lungs may have more to do with their proneness to the latter, than the abundant supply of oxygen. My own experience agrees with the inference of Rokitansky; for I have observed that organic diseases of the heart, spasmodic asthma, and pulmonary emphysema, all of which increase the venosity of the blood, resist or retard the deposition of tubercles. It has repeatedly happened to me to meet with a member of a phthisical family affected with morbus cordis, or spasmodic asthma, who has survived the age at which other members have been attacked with phthisis. It is nevertheless true that congestion of the lungs, as in fever (§ 293), favours the development of tubercles, but congestion is not identical with venosity.

The elements of cacoplastic diseases chiefly to be kept in view in considering the treatment are:—1. *the disordered condition of the blood, and its causes;* 2. *the disordered distribution of the blood, and its causes; and* 3. *the presence of the deposit, its intrinsic changes, and its effects.*

The more constant and important condition to be considered in the treatment of cacoplastic and aplastic diseases, is the one first named—the depraved state of the blood; and this is of more consequence in treatment, and demands more attention according as the deposits are more extensive or degraded. The first point to be attempted is the removal or counteraction of the several causes already enumerated (§ 564), as contributing to induce the diseased condition of the blood. Thus a sufficient supply of food of a nutritive and digestible quality, and especially comprising proteinaceous articles (§ 60) of the highest order; free access to pure dry air and to light, while the warmth of the body, and particularly of the surface and extremities, is carefully secured by adequate clothing, and regular exercise proportioned to the strength—the removal or counteraction (so far as is possible) of derangements of digestion and excretion, and of depressing mental or bodily influences;—these are all objects that should be assiduously aimed at. When excessive losses of blood, or other evacuations, have lowered the plastic powers of nutrition, a generous animal diet, and tonics, especially such as contain iron, are especially demanded. Where the altered condition of the blood can be traced to an excess of ill-developed fibrin accumulating after the cessation of growth, the termination of pregnancy, the amputation of a limb, or the sudden stoppage of an habitual discharge, purulent or otherwise, means should be taken to eliminate the superfluous matter from the system, either by increasing the natural secretions, or by establishing an artificial drain through blisters, setons, issues, or suppurating counter-irritants; whilst tonic and invigorating measures are also adopted to raise the plasticity of the blood to a higher standard. Some of the remedies, to be more fully alluded to in relation to the third class of considerations, are occasionally effective in promoting these objects also, such as cod-liver oil, nitric acid, and combinations of iodine, which have a direct influence on the nutritive functions.

The foregoing measures are preventive rather than curative; but in so far as they may succeed in arresting the augmentation

of deposits already formed, and in improving the nutritive function in general, they may be looked to cause the gradual absorption of tubercles, or their quiescence in contraction (§ 556) or calcareous transformation (§ 561).

566. The second element to be borne in mind, in relation to treatment, namely, *disordered distribution of blood, and its causes,* is identical with the varieties of local hyperæmia, which have been fully noticed as concerned in producing the higher kinds of cacoplastic deposits (§ 553), and in promoting the formation and changes of that of a still lower character (§ 560). Hence the measures that are appropriate to remove determination of blood and congestion are often serviceable in the prevention or treatment of cacoplastic deposits; but it is very rarely that other than *topical* forms are required, such as local blood-letting, the application of counter-irritation, and the use of revulsives and derivants (§ 174). No remedial influences of this class have proved in my hands more generally useful than the milder counter-irritants, and rubefacients extensively and regularly applied by friction over a large extent of skin. They act not only as revulsives, diminishing the congestions and irritations of internal organs; but they also, by increasing a free circulation of the surface, promote the purification of the blood by perspiratory excretion, and by some degree of oxidation by the action of the air.

567. The third class of objects to be regarded in treatment, relates to the deposit that is already formed, and the possibility of its removal or reduction to a quiescent and harmless state. This latter end is not easily attained, because the deposits are for the most part non-vascular, and but little under the influence of absorption and of the blood-currents by which all organic changes are carried on. These substances being unlike to the products of inflammation, and to simply overgrown texture, the changes of absorption are necessarily slow in reaching them, solid and remote from vessels as they are; and it is doubtful whether any remedial influence that can be brought to bear upon them has really the power to effect their removal, otherwise than by the simultaneous destruction of the texture in which they are contained. Mercury pushed so as to affect the gums, does seem to me to hasten the softening and evacuation of pulmonary tubercles; but it does this by such a work of destruction, that its agency is, on the whole, injurious rather than beneficial. Drs. Graves and Stokes,

as well as other physicians, have, however, recommended that mercury should be given in the earliest stage of tuberculous disease. My own experience leads me to avoid the specific influence of mercury in all cases of mere tubercle; but I have often employed it with advantage in subacute and chronic inflammation simulating tuberculous disorder, and even where tubercle probably co-existed in a limited extent. I am less doubtful of the utility of mercury (introduced by the skin) in incipient cacoplastic or tuberculous deposit upon serous membranes, and particularly on the peritoneum, which is commonly one of the results of chronic inflammation. I have successfully treated several cases, in which the signs and symptoms left no doubt as to the existence of tuberculous peritonitis, by applying ointment of iodide of mercury to the abdomen (covering the skin with India rubber cloth), and giving iodide of potassium internally. Whether mercury is of any use in granular disease of the liver and kidney, is a matter of considerable doubt. Alkalies and their carbonates, and iodide of potassium have better claims to attention, although it is by no means certain that they possess much power. The occasional subsidence of external scrofulous tumours under their exhibition, is the best argument in their favour; and there is this advantage attending their employment, that when judiciously administered for long periods, they do not materially injure either the blood or the constitution. They act best, and are borne the longest, when combined with some amylaceous or mucilaginous compound, such as decoction of Iceland moss, or fluid extract of sarsaparilla, to which may be added a little tincture of hop, or some other bitter. I have found this combination useful in the early stages of tuberculous disease, where there was no fever, active inflammation, or tendency to hæmorrhage. Whether the iodine and alkali ever directly promote the solution or absorption of tuberculous matter, I am still in doubt; but I am clear that the signs of the presence of limited tubercles have, in many instances, diminished during their use, and the patients have regained colour, flesh, and strength. Other combinations of iodine, particularly with iron, have also been recommended in scrofulous disease. The iodide of iron, and chalybeates in general, are decidedly beneficial in cases of anæmia or weakness in scrofulous subjects, without much fever or local inflammation; but I

have no reason for believing that they actually promote the removal of tubercles already found.

568. But there are yet other agents, which have been found to be of decided efficacy in cacoplastic and aplastic diseases, whose mode of operation may be intimately connected with some of the considerations we have recently been entertaining. It has been seen that cacoplastic deposits consist of granular albumen or protein, with a little (insoluble) gelatine, and minute molecules of fat contained in the granules; and that the more granular the deposit, and the lower it is in the scale of organization, the more the fatty molecules abound, being so much increased in opaque tubercle and atheroma, that they coalesce and form large oil globules, and sometimes solid concretions of fat. The most effectual solvents of all these constituents are caustic alkalies, and especially the liquor potassæ, which dissolve protein, and form a liquid soap with oil. But it is impossible to administer these agents in sufficient quantity to obtain their influence through the blood, both because they would irritate the stomach and vessels too much during their passage, and because they would soon meet with such an amount of acid, (particularly the carbonic,) as would deprive them of the greater part of their solvent power. The same remark applies to the employment of acetic acid, which has been also recommended as a solvent of solid albumen.

Other agents which have been extolled as remedies for tuberculosis might be supposed to act by dissolving the fatty constituents of tubercle, and in this way promoting its disintegration; of this class are naphtha or pyro-acetic spirit, oil of turpentine, tar, sulphuric ether, and various fixed oils. Naphtha, which has been so highly recommended by Dr. Hastings in the treatment of phthisis, has in my hands proved serviceable in a very limited number of cases; but its efficacy has seemed to me to be due to its checking profuse purulent secretion, and the cough, hectic, and wasting accompanying it; and in this it has appeared to me to operate like the balsams, gum resins, and turpentines, rather than by any specific influence on the tuberculous deposit. So, like these, it often acts unfavourably by checking expectoration, and excites pain and tightness of the chest, and hard cough, which may even end in inflammation or hæmorrhage. Its utility is also limited by its tendency to irritate or disorder the stomach.

Fixed oils possess a solvent power over the fat of tubercle, and they exercise no irritating operation on the living textures: they may therefore be administered in quantities ample enough to justify the expectation, that some decided influence may be ensured from their thoroughly and abundantly pervading the structures of the body. The greater number of the fixed oils, however, if taken in any quantity, soon disagree with the stomach, bowels, or liver, causing nausea, inappetency, diarrhœa, bilious disorders, and other unpleasant effects, such as have been ascribed to excess of fat in food (§ 60). Such consequences have been found to ensue when olive or almond-oil, or cream, has been taken for several days. In this respect, as well as in its superior utility in the system, the cod-liver oil surpasses every other oil; for it has no purgative property, and, with proper management, may, in a great majority of cases, be made to agree well with the stomach. It is not improbable that its more easy digestibility in some measure depends on its containing biliary principles: in many instances it has a marked effect in increasing the secretion of the liver; and if this is sufficiently carried off by the several processes of combustion and elimination, no tendency to sickness results from its use. It is therefore not surprising that cod-oil can be administered in larger quantities, and for a longer time, in cold seasons than in warm; to persons who can use exercise, than to the sedentary; and especially to those in whom the action of the bowels is regular and sufficient, than to those subject to costiveness or irregularity. With many weakly persons it proves of great assistance to the digestive function, in promoting a secretion of bile; and in not a few instances I have found it effectual in improving and rendering more fluid this secretion in persons liable to gall-stones or obstructions from inspissated bile. On the other hand, it is apt to disagree in cases of inflammatory dyspepsia, especially that affecting the duodenum; in those of hepatic congestion, with fulness and tenderness in the hypochondria, and in all states of acute inflammation or fever. All such affections should be relieved by saline effervescent draughts, mild mercurial aperients, and such means, before the oil is administered: and in the case of persons prone to these disorders, the same medicines may be frequently required during its use.

The beneficial operation of cod-liver oil extends to almost every function and structure of the body. In cases most favourable for

its use, there is a progressive improvement in digestion, appetite, strength, flesh, and complexion; and various morbid conditions diminish in a very marked manner. Thus purulent discharges are lessened, ulcers assume a healthier aspect, colliquative fluxes cease, the natural secretions become more copious, and the pulse less frequent. It is difficult to comprehend how it can produce such marvellous and manifold salutary effects; and it must be admitted that its modes of operation are but obscurely understood. Certain properties, however, may be pointed out as peculiar to this oil, and these may have some share in contributing to its remedial powers. Thus it forms an emulsion more readily than other oils, and even saponifies with alkaline carbonates; and this circumstance may serve to explain its easier digestibility and absorption from the alimentary canal. Probably connected with the same property is its containing more or less of the distinctive constituents of the bile, the salutary operation of which, on the hepatic function, has been already alluded to. Its superior penetrative and suppleing property has always rendered cod-liver oil most valuable in currying leather; and previously to its introduction into medicine, this was its chief commercial use.

Thus we have an oily matter—well borne by the stomach, easily diffused by emulsion through the alimentary mass, readily absorbed by the lacteals, where it contributes to form a rich "molecular base" in the chyle; apt to saponify with the basic salts of the blood, and when diffused in this fluid throughout the capillaries of the body, capable of penetrating to all the textures, and of exercising its solvent and softening influence on the solid fats of old deposits, and forming abundant molecular nucleoli for the formation of new cells. The oil in its highly divisible state supplies and renews this fat in a form and mode most conducive to active and healthy nutrition. Its fluidity and its divisibility enable it to pervade all the tissues, and to penetrate even into imperfectly organized deposits, and so to soften their concrete fatty molecules, and to render permeable and supple their whole mass, as to bring them more under the influence of the adjoining living parts, through whose circulation either their vitality and nutrition may be improved and maintained, or, if incapable of such improvement, their substance may be gradually dissolved and absorbed away. Such appears to me the most probable mode of operation peculiar to cod-liver oil, assuredly the most efficacious of all medicinal

agents in the treatment of cacoplastic and aplastic deposits. It is true that it also contains iodine, bromine, phosphorus, and other peculiar constituents, to which its efficacy has been ascribed; but not only is the proportion of these constituents too minute to have much influence in determining results so prompt and so considerable as those which are often obtained from the administration of cod-liver oil, but also it may be objected that these several elements have been used in various other combinations without an approach to such satisfactory results. On the other hand, certain other oily matters have in a limited number of cases been exhibited with a success more resembling that commonly attending the use of the cod-oil. Thus cream, bacon, mutton suet in milk, cocoa-nut oil, almond-oil, and neatsfoot-oil, have been found by several practitioners to be beneficial in the same manner as the fish-oil; and although the testimony in favour of all these falls far short of that in favour of the latter agent, yet it approximates them to it much more nearly than any evidence which can be brought in favour of iodine, bromine, or any other chemical element or combination.

The present state of our knowledge appears therefore to justify the conclusion that cod-liver oil is chiefly beneficial as an oil, supplying a material which enriches the blood, affords both combustive and nutritive elements, and penetrates throughout the tissues and deposits, softening their concrete fat, and rendering more supple their solid fabric. The superiority of cod-liver oil over other oils seems to consist in its easier digestibility by the stomach and chylopoïctic organs, which is probably dependent on the bile, and perhaps other ingredients which it contains. The nutrient properties of cod-oil have been proved by its increasing the proteinaceous constituents of the blood, (except the fibrin, which is diminished,) and Dr. Theophilus Thompson has ascertained that the same result has followed the use of the cocoa-nut oil. (Proceedings of the Royal Society, 1854.)

The limits of this work prevent me from entering into further details on the use of cod-liver oil in particular diseases; but with regard to pulmonary consumption, after further experience in several thousand cases, I do not hesitate to repeat a statement which I published seven years ago;—*That the pure fresh oil from the liver of the cod is more beneficial in the treatment of pulmonary consumption than any other agent, medicinal, dietetic, or regiminal, that has yet been employed.* (London Journal of Medicine, Jan., 1849).

The amount of good wrought by the oil varies greatly: in some cases being very slight and transient; in others, equally decided and lasting: in some, it only lessens and retards the progress of the disease; in others, it arrests it and effects a cure more or less permanent. The average duration of life in pulmonary consumption was by Laennec and Louis reckoned at two years. So far as I have been able to estimate by a hasty calculation, this average is prolonged to four years by the aid of the cod-liver oil and other means.

As some difference of opinion seems to exist as to the kind of oil that is best for exhibition, it may be well to say a few words on this point. The dark-brown cod-liver oil of commerce, which is used by curriers, was that employed by Dr. Bardsley in this country fifty years ago; and is still recommended by Dr. Darling, who has prescribed it with great success in scrofulous affections during the last thirty years. A brown oil of more or less impurity has also been in use as a remedy, first by the people, and subsequently by the profession, in Holland, Germany, Norway, and other northern parts of the Continent, for many years past. In 1841 Dr. Hughes Bennett published a work on the oil, recommending its use on the authority of several continental practitioners, and giving preference to a light-brown oil. At this date I began to prescribe this oil; but I found so much objection on the part of patients, and sometimes such real disorder produced by attempts to take it, that I came to the conclusion that, however Dutch and German stomachs might bear it, English ones could not, at least among the upper classes. It was not until the pure pale oil was brought under my notice, that the difficulties in administering it gave way; and during the last ten years, I have prescribed it for nearly nine thousand patients, and with such success that it was taken without material difficulty by ninety-five per cent. of the whole number; and of those who thus took it, fully eighty-five per cent. derived more or less benefit from its use. This experience, which is in accordance with that of many of my professional friends, is at least quite as strong as any that can be adduced in favour of the brown or impure kinds of oil; and it does seem absurd to recommend the exhibition of the remedy in its offensive form, when the pure fresh oil has been proved to be at least equally efficacious.

The dark-coloured and strong-smelling oils owe their offensive

properties to the partial decomposition and putrefaction which the livers undergo before and during the process of separating the oil from them. They thus acquire a strong fishy smell and taste, like that of lamp-oil, which, although highly disgusting to most persons, are not disliked by a few who resemble Russians and Laplanders in their tastes. Dr. De Jongh, who has given the sanction of his name to an article widely advertised in this country in the last few years, strenuously advocates the superiority of the light-brown oil; but, as Dr. Garrod has well shown (Brit. and For. Med.-Chir. Rev., Jan., 1856), the facts which he adduces by no means bear out his assertions; and the general results of chemical analysis, as well as of clinical experience, are altogether in favour of the pure pale oil as carefully prepared in this country and in Newfoundland. The process is thus described by Dr. Garrod:—"The livers are collected daily, so that no trace of decomposition may have occurred; carefully examined, in order to remove all traces of blood and impurity, and to separate any inferior livers: they are then sliced, and exposed to a temperature not exceeding 180° Fahr., till all the oil has drained from them. This is filtered, afterwards exposed to a temperature of about 50° Fahr., in order to congeal the bulk of the margarine, and again filtered* and put into bottles well secured from the action of the air." (Brit. and For. Med.-Chir. Rev., Jan., 1856.) In fact, the great object to be kept in view in the preparation of the oil, is to separate its more liquid part in the simplest and speediest manner from all contaminating matters, so that it may be administered in the pure state in which it exists in the cells of the liver of the living or recently dead fish. Much meddling or tedious elaboration will injure it as much as carelessness or roughness of preparation; for exposure to the air soon turns it rancid and spoils its freshness as much as if it remained in the livers until they became stale. The sweetest cod-oil, if rubbed on the skin, acquires a very offensive smell in the course of a few minutes; hence the stench produced by the practice of rubbing the oil on the surface of the body is so sickening as to render this mode of exhibition intolerable with many individuals. If inunction should prove to be as

* I have always recommended the oil without the solid margarine and stearine, both from the experience that it agrees better with the stomach, and from the views which I entertain as to its mode of action. Dr. Garrod has tried the solid residuum of the oil, and found that the few patients who were able to take it derived no advantage from its use.

serviceable as stated by Professor Simpson, it would be much better to use almond or olive-oil rather than cod-oil; for I feel sure that, among the upper classes at least, it would soon bring the latter into disgrace, to attempt to administer it in a mode which renders it truly disgusting.

When we consider the amount and variety of beneficial effects which result from the use of cod-liver oil, and that its exhibition ought to be continued not for days and weeks only, but for months and years, we shall perceive the vital importance of obviating as much as possible all objections of taste, smell, nauseousness, and other causes of offensiveness to the senses, stomach, or system, which may impede its continued administration. I will therefore add a few directions as to the particulars of its exhibition.

(1.) *The Oil.*—It should be as fresh, and as free from taste and smell, as it can be procured. Several of the leading chemists in London (Messrs. Bell, Squire, Taylor, Allen, Savory, Curtis, Fincham, and others) prepare during the winter season, an oil, which, for sweetness and freshness, surpasses any obtained from abroad; and from December to the end of June I have found the London-made oil generally prove the best. Soon after midsummer, a supply is imported from Newfoundland, and that prepared there with great care by Mr. Fox is generally excellent, being at this season quite equal to the home-made oil, with the recommendation of being considerably cheaper.* The oil should be kept in a cool place, in moderate-sized bottles, well corked, and not opened or exposed to the air more than is necessary.

(2.) *Mode of Exhibition.*—Many persons, especially children, can take the oil alone without any difficulty: and in such a case it seems needless to recommend any adjunct. Yet even with these, if the remedy is to be continued for a long time, it is better to give some agreeably-flavoured tonic with it, for this prevents the palate and stomach from being palled by repetition, which is very apt to occur when the oil is long taken alone, however well borne and even relished at first. To the great majority of patients it is more agreeable to disguise the taste of the oil; and this may be done by giving it in another liquid which may also act as an agreeable tonic to the stomach. Some chemists have endeavoured to render the oil more palatable by the addition of an essential oil or

* A good pale oil has also been recently imported from Norway, of a quality much superior to that sold as Dr. De Jongh's oil.

other flavouring matter; but, according to my experience, this does not fully disguise the taste or smell, and it increases the tendency to unpleasant eructation afterwards. The best way is to take the oil floating on a well-flavoured tonic, such as the compound infusion of orange-peel, with the addition of a little diluted nitric and hydrocyanic acids, and either sweetened with syrup, or rendered more bitter by the addition of a little tincture of hop or calumbo, according to the fancy of the palate or the requirements of the stomach. The bulk of the whole dose should be small, so that it may be swallowed at a single draught; therefore the quantity of the vehicle should not exceed a tablespoonful, or half an ounce, with a teaspoonful of oil, which is to be gradually increased to a tablespoonful. The dose of oil should rarely exceed a tablespoonful twice or three times a day: when a larger amount is taken at a time, it generally either deranges the stomach or liver, or some of it passes unabsorbed by the bowels. The diluted sulphuric, phosphoric, or nitro-muriatic acid may be substituted for the nitric in the vehicle, and form agreeable varieties, better suited in some cases; but as a general rule, I have found the nitric acid the best, as tending more to correct the richness of the oil, and causing less tendency to lithic deposits in the urine. The chief advantage of exhibiting the oil in such a tonic as that now recommended, is that, in addition to disguising the taste of the oil, the tone of the stomach is also kept up, so that it bears the oil in full doses and for a long period: and in this respect it is superior to orange or ginger wine, aromatic waters, coffee, milk, and other vehicles that are occasionally used. In cases of peculiar weakness of stomach, with tendency to nausea, I have often given a fortieth or a thirtieth of a grain of strychnine in solution with each dose with great success. Infants and young children generally take the oil without difficulty; and it is easy to disguise it in a very palatable and attractive form, in an emulsion with mucilage or the yolk of an egg, and a flavoured syrup.

(3.) *Time of Exhibition: Diet, &c.*—General experience has proved that the oil agrees best when taken during or shortly after a meal. Formerly I recommended it to be taken from one to two hours after; but I have lately found that it rises less, and leaves the appetite more free for the next meal, if swallowed ten or fifteen minutes only after the meal. When taken on an empty stomach, it often causes eructations, with a rancid, unpleasant taste of the

oil for hours. In most instances, after the two or three first meals is the best time, as the stomach is, with the body, more fatigued towards the close of the day; but I have known several persons to take it well at bed-time; these are generally good sleepers, whose sound repose hides any symptoms of disagreement.

With some individuals the oil agrees so well, and so much improves their digestive powers, that they require little or no restrictions in diet; but this is not the case with the majority. The richness of the oil does prove more or less a trial, sooner or later, to most persons; and to diminish this trial as much as possible, it obviously becomes proper to omit or reduce all other rich and greasy articles of diet. All pastry, fat meat, rich stuffing, and the like, should be avoided, and great moderation observed in the use of butter, cream, and very sweet things. Even milk in any quantity is not generally borne well during a course of oil; and many find malt liquor too heavy, increasing the tendency to bilious attacks. A plain nutritious diet of bread, fresh meat, poultry or game, with a fair proportion of vegetables and a little fruit, and a moderate quantity of liquid at the earlier meals, commonly agrees best, and facilitates the exhibition of the oil in doses sufficient to produce its salutary influence in the system.

But no remedy, however beneficial, should lead to the neglect of those general and hygienic measures by which the constitutional health may be promoted and sustained; or, in other words, by which the great functions of circulation, respiration, digestion, absorption, and excretion, may be kept at the healthy standard. Mention has so often been made of these measures, that it would be superfluous to particularize them again; but it may not be inexpedient, in concluding this subject, to allude once more to such of them as promote the absorption of cacoplastic and aplastic deposits.

That such absorption is a possible event, is indisputably proved by the changes that these deposits undergo in chemical composition, as well as in physical condition, in process of time (§ 556, 561). The most salutary of these changes are quickened, and the removal of the most injurious portion of the deposit is brought about, by maintaining as free and active a circulation through and near the affected part as can be carried on without inducing irritation or hyperæmia. Hence the utility of regular exercise, of

[redacted] of the surface in the vicinity of the seat of the [redacted], and of rubefacient applications or salt water aspersions. The more vigorous circulation thus excited, promotes the gradual [redacted] of the deposits, chiefly by the oxidating influence of the current of arterial blood that is thrown with more force through the neighbourhood. This probability naturally suggests the inquiry whether it is possible to aid this process by oxygenating the blood more highly than can be done merely by the free respiration of pure air? I have already suggested that it is probable that such agents as nitric and nitromuriatic acid and chlorate of potass, may contribute to this object; and I now again allude to this, because I have found their continued use beneficial in many cases, after inflammation, when circulation and absorption were slack, and cacoplastic effusions were accumulating and threatening further mischief. These oxygenating medicines also sometimes produce decided improvement in the general and local symptoms of scrofulous and tubercular disease during the maturation and softening of their deposits. Their utility is however limited by their tendency to irritate the alimentary canal when they are given largely or continued long; but they may commonly be advantageously used during the intervals, when courses of cod-liver oil, of iron, and of other tonics are temporarily interrupted.

SECTION VII.

MORBID GROWTHS.

569. Under the term *morbid growths* or *tumours* may be arranged certain structures which are developed in the animal body *in addition to* the natural textures. They differ from hypertrophy and from euplastic deposits, in the peculiarity of their structure; and from cacoplastic and aplastic deposits, in their higher degree of organization. In other words, they are distinguished from hypertrophy, and euplastic formations, by the *kind* of their vitality; and from degenerations and cacoplastic deposits, by the *degree* of their vitality. They are, in fact, new structures; and although some of them in general characters, and most of them in elementary composition, resemble normal textures

of the body; and although all derive their nourishment from the blood; yet, in their origin, and mode of growth, they are more essentially distinct from the natural structures than are any of the results of diseased nutrition hitherto considered. For these reasons, they have been termed *new* and *parasitical* growths; and the latter term is the more applicable to them, because their existence and method of increase cannot generally be traced to such variations in the local circulation as are found to be chiefly concerned in producing and influencing the modifications of nutrition hitherto noticed.

Morbid growths have been divided, for distinction's sake, into *analogous,* or those whose structure somewhat resembles some natural texture (including false membranes, &c.); and *non-analogous,* or *heterologous,* those which have no parallel in the healthy state of the animal economy. But this classification is inconvenient, because it is also applied to the products of diseased nutrition that are arranged as another group (hypertrophy and deposits): and it is often inapplicable, inasmuch as many morbid growths are essentially compound, comprising some forms that resemble natural textures, and others that do not; all being, nevertheless, composed of similar elementary molecules; this is especially the case with carcinoma.

The classification into *non-malignant* and *malignant,* here adopted, is therefore more useful in a practical point of view, although it may not be easy to make it precisely applicable to all cases.

SECTION VIII.

NON-MALIGNANT GROWTHS.

570. The term non-malignant properly belongs to those growths or tumours which have their seat in one part of the body, without any tendency to produce similar formations in other parts; and which arise among, but do not invade or penetrate, the natural structures; and, if they prove injurious, it is by their bulk or position, or by the extent to which they abstract nourishment from the rest of the body.

571. The most simple of the morbid growths are *serous cysts,*

which consist of a shut sac, "containing serum, and formed of condensed cellular substance resembling serous membranes, which are formed gradually around a clot of blood, or any foreign substance in the system; and are frequently developed spontaneously in various parts of the body. They are frequently attached to the natural serous membranes, but sometimes quite separate from these; sometimes solitary, sometimes set together in clusters; and their size and shape are very various. They must be distinguished from enlargements of natural cavities, such as the calices of the kidneys, or Graafian vesicles in the ovaries. They are often unconnected with disease of the adjacent textures; but in some cases, these textures are found either wasted by absorption" (atrophy from pressure, § 532), "or disorganized by inflammation around them. There is no evidence of their being generally connected, in their commencement, with inflammatory action; and when they are small, their existence is often not denoted by any symptoms whatever."*

Besides the exceptions alluded to above, there are several other cases of apparent tumours which do not really belong to this class of formations, but are rather results of hypertrophy, dilatation, or unusual development of a natural structure, and therefore must be referred to a previous paragraph (§ 528). The enlarged bursæ, occurring in situations subjected to pressure; the dilated mucous follicles of the cervix uteri; the cutaneous follicular distension from fatty or other matter which constitutes subcutaneous *adipoma* and *melliceris;* the obstruction of, and concretion within, the salivary ducts known as *ranula,* are all of this kind. I am also inclined, with Dr. Hodgkin, to extend the same remarks to the small serous cysts frequently found in the kidneys and liver, which I have before described as portions of secretory ducts obstructed and distended with serum, (p. 253, note). It may be fairly questioned, too, whether some serous cysts are not simply due to enormous enlargement of the primitive or compound cells of which many textures are partly composed. Dr. Hodgkin has ably advocated an opinion of this kind, and has applied the same principle to explain the production of more solid and complex growths, by the formation, multiplication, and compression of a series of cells.†

* Alison's "Outlines of Pathology," p. 231.

† Med.-Chir. Trans. vol. xv. part 2.

572. Cysts, somewhat resembling those above described, are, however, sometimes found filled with different unorganized contents, and they then constitute the simplest kind of *encysted tumours;* these form in various parts of the body that have a cellular structure, and they have received names descriptive of their contents: thus they are called—*hygroma,* when they contain a nearly serous fluid, and form encysted dropsy if they attain a large size; *hæmatoma,* when their contents are bloody; *steatoma,* or *lipoma,* when they are of a fatty nature; and *atheroma,* when made up of an opaque pulpy matter of plaster-like appearance.*

These cysts are probably often in the first instance formed of extravasated blood or fibrinous matter, whose exterior becomes organized into a sac, the inner surface of which, according to Vogel, secretes an epithelium; whilst the interior is more or less removed, and either replaced by serum, which may be thickened by epithelium scales, or converted into fatty, or even osseous matter, in the same manner as aplastic deposits (§ 561), and the contents of old abscesses.† When such tumours form under the skin they often contain epidermis scales, which either render the fluid opaque and thick, or agglutinate with it into a horny solid. If in the vicinity of hairy parts they occasionally have hair in them. In some instances cholesterin has been found in them in great abundance; and this not only in cysts connected with the liver, but also in the large, and often compound, cystiform tumours connected with the ovaries. Cysts in these last organs have been known to enclose perfectly formed teeth and bones as well as hair.

573. Complex cystiform tumours are more varied in their structure, and exhibit further deviations from normal organization. They chiefly occur in connexion with glandular organs or such as naturally possess cysts or vesicles, as for instance, the ovaries.

A still more complex kind of tumour is that which is generally designated by the term *sarcomatous;* this consists of solid matter more or less organized, and mostly bearing a resemblance to one or more structures naturally existing in the body, and especially

* For examples of cysts of different kinds, see Pathological Trans., vol. vi., pp. 8, 12, 335; and for a further description, see Mr. Paget's "Lectures on Surgical Pathology," Vol. II.

† Vogel suggests that cysts, with various contents, may originate in old abscesses which have never opened, and whose pus has gradually undergone transformation. Cysts in the liver, filled with a gelatinous, and in some instances a putty-like matter, and commonly passing for tubercle, are most probably produced in this way.

in the part in which the tumour grows. Thus there are;—*fibrous tumours,* consisting of densely compacted fibres, scantily supplied with blood-vessels, generally slow in growth, and, like fibrous deposits, liable to ossification. *Steatoma* or *adipose sarcoma,* resembling natural adipose texture, but often rendered more dense by combination with some fibrous structure;—*Chondroma,* or *cartilaginous tumour,* forming rounded masses that have a considerable analogy with cartilage, but that are also apt to be mixed with *bands of fibrous* texture, and are liable to ossification;—*Vascular tumours,* (*Hæmatoma, erectile tumours,*) consisting of a congeries of blood-vessels of considerable size, apparently enlarged capillaries, with more or less connecting filamentous tissue. These last are greatly modified according to the freedom with which they communicate with arteries; when supplied by large arteries they are florid in colour, they pulsate; and if large, the pulsation is attended by a blowing or rasping sound such as is heard in vascular bronchocele: when the arterial communication is not free, the tumours exhibit the darker hue of venous blood.*

Dr. Hodgkin considers that the complex cystiform tumour, such as occurs in the ovary, is a type of the mode in which morbid growths originate in general, not excepting those of a malignant kind. From the internal walls of one original or parent cyst, there spring a number of other cysts, containing different kinds of matter, and as these grow, they fill the original cyst, and project beyond it, other cysts being produced within them; in this way an extension of substance takes place, subject to modifications from the nature of the texture in which it occurs, as well as from that of the contents of the cysts. In solid structures, like dense cellular membrane, the cysts are so compressed as to present the appearance of fibres radiating from a centre, and lose all their liquid contents. Sometimes the adjoining textures, as well as the walls of the cavities, inflame and cohere, and so obliterate the cystiform character of the tumour.

574. The pathological cause of morbid growths is involved in much obscurity. At present nothing further can be surmised than that these arise from alteration of the vital properties of some of the molecules of the textures in which they are developed; so

* For further details respecting the pathological character of tumours, the reader is referred to Rokitansky's Pathological Anatomy, Paget's Lectures on Surgical Pathology, and the Transactions of the Pathological Society of London.

that, instead of being assimilated to the textures, and conforming to the ordinary laws of their growth and decay, these molecules spring into existence and attach themselves together in modes more or less peculiar, and behave themselves more or less independently of the influences of the adjoining living parts. Where these modes are the least peculiar and the most dependent on the nutrition of the adjacent structures the growths are the least abnormal, vary the least from these structures in their origin and course, more resemble either hypertrophy (§ 525) or euplastic deposits (§ 547), and do mischief rather by their size or situation than from their intrinsic nature. Where the mode of growth is the most peculiar, and where it is the most independent of that of the adjoining textures, the resulting tumours are the most abnormal in their nature and mode of development; and approach most in character to malignant disease, operating injuriously, not only by their bulk and position, and by their abstraction of the nourishment of the body, but also by their tendency to encroach and supersede natural structures, and to contaminate distant parts through the blood.

575. Near the outer boundaries of the group of non-malignant growths, may be placed those peculiar bodies, called *hydatids* or *acephalocysts*. These are unlike all other morbid productions of the class, both in the matter of structure and contents, and they are quite detached from the textures in which they occur. It may therefore be inferred that they possess an entirely independent vitality. This, although of a low degree, is indisputable, and is exhibited, (1) in their power of self-nutrition, expressed by their progressive increase in size, and by the peculiar nature of their walls, which are much more elastic than any normal animal texture; (2) in their power of secretion, manifested by the presence within their cavities of a limpid and colourless liquid, which is constant in its character, whatever be the nature of the matter in the serous cyst that separates them from the ordinary textures of the frame; (3) in their power of reproduction by gemmation, the young gemmule being developed in the membranes of the parent cyst, and thrown off either internally or externally according to what the species may be. Professor Owen* describes the hydatid as "an organized being, consisting of a globular bag, which is composed of condensed albuminous matter, of a laminated texture,

* "Cyclopædia of Anatomy," &c., article *Entozoa*.

and containing a limpid colourless fluid, with a little albuminous, and a greater proportion of gelatinous substance." He adds, "As the best observers agree in stating that the acephalocyst is impassive under the application of stimuli of any kind, and manifests no contractile power, either partial or general, save such as evidently results from elasticity—in short, neither feels nor moves—it cannot, as the animal kingdom is at present characterized, be referred to that division of organic nature. It would then be a question, how far its chemical composition forbids us to rank the acephalocyst among vegetables. In this kingdom it would obviously take place next those simple and minute vesicles which, in the aggregate, constitute the green matter of Priestley, (*Protococcus viridis, Agardh*;) or those equally simple but different coloured *psychodiariæ*, which give rise to the red snow of the arctic regions, (*protoccus kermesianus*). These, first-born of Flora, consist, in fact, of a simple transparent cyst, and propagate their kind by gemmules developed from the external surface of their parent."

The researches of Schleiden, Schwann, and their followers, have thrown some light on the probable origin of hydatids, by showing that the primitive cells of animal, as well as of vegetable structure, are to a great extent like hydatids in their anatomical composition, growth, and mode of reproduction; for the hydatid appears to be a cell, in the interior of which are developed nuclei and nucleoli, the germs of young cells. But if it be presumed, on this account, that hydatids are really *offsets* of living structures of a high order in the scale of development, and capable of living apart from the general mass of the body, it still remains a mystery how this divided or detached life can be thus acquired by certain molecules on rare occasions, contrary to the usual law. The imagination may conceive, perhaps, that there is some analogy between hydatids and the polype tribe of animals, which can be indefinitely propagated by division; and that the conditions of the body, in which hydatids are produced, reduce the plasma of certain parts to the standard of this grade of life; but such conception does not soften the difficulty much, and indeed must be held to be too exclusively a speculative matter to be dwelt on here.

576. The situations in which hydatids have been most commonly found are the liver, the lungs, the spleen, the kidneys, and the ovaries. M. Andral records an instance in which he found

hydatids in the blood within the pulmonary veins; and there was also a large cyst full of hydatids in the liver.* The condition of the system in which they have been most frequently found to occur is that of cachexia and mal-nutrition. They are usually contained in a serous or protective cyst (§ 571) formed by the surrounding texture; and the symptoms which they occasion are merely such as are necessarily caused by their bulk and position, making them compress, displace, and irritate organs, and causing atrophy and inflammation in their textures. In the containing cyst there is commonly observed more or less of opaque laminated matter, which appears to be the debris of collapsed hydatids; indeed, some that retain the globular form exhibit the commencement of decay, in an opacity and wrinkling of their walls, and in the changed colour of their contents. But I have likewise had frequent occasion to notice a considerable quantity of opaque yellowish pultaceous matter mixed with the collapsed hydatids, and lining the containing cyst: this, under the microscope, appeared to consist of granular matter and imperfect cells mingled with much fat, and in one instance, where the hydatid sac lay between the liver and the diaphragm, there were abundant crystals of cholesterin: I have therefore been led to regard this opaque matter as a deposit from the surface of the sac, subsequently degenerated into aplastic and fatty substance.

577. The *echinococcus* is a variety of hydatid, which differs from the form alluded to above chiefly in its having a yellowish and tougher outer tunic, and in its containing distinct animalcules within it, (*vermiculi echinococci.*) It has been found in the liver, spleen, mesentery, and substance of the heart, and upon rare occasions in the urine. The *cysticercus* occurs in muscular structure, and in one instance was seen in the aqueous humour of the eye. It has a distinct structure, consisting of a cystiform body, and a head provided with suckers and hooklike processes, by which it attaches itself. The *distoma hepaticum,* or *liver-fluke,* is rarely observed in the human subject. It is the supposed cause of the rot in sheep, and was observed by Andral and Delafond chiefly in those animals in which dropsy was present, and in whose

* For examples of Hydatids, see Pathological Transactions—in the Pericardium, vol. vi. p. 108; in the Peritoneum, vol. v. p. 303; in Cellular Tissue, vol. v. p. 298; passed by the Urethra, vol. v. p. 298, &c.

blood there was a defect of albumen (§ 222). The rot chiefly attacks sheep fed in wet clayey pastures.

The subject of intestinal worms belongs to special pathology.

578. There is but little to be said regarding the *medical treatment* of morbid growths. To such kinds as approach most nearly in character to the natural textures, the observations that have been made on hypertrophy (§ 529) and euplastic deposits (§ 552) apply. So far as they originate from, or are augmented by, local determination of blood, or any other kind of hyperæmia, the remedies for those states may be looked to for the retardation of their development. But as their especial peculiarity is an alteration of the vital properties of the primitive molecules of textures, little is to be expected from measures which act only on the quantity of the nutritive material. Indeed, in many instances, morbid growths seem to originate in connexion with a depressed rather than with an exalted condition of the vascular functions; and in such as are most like to parasites in nature, the general or constitutional powers are weakened in proportion to their development. Hence, the treatment indicated as appropriate for such cases is one of a supporting and tonic kind, with due regard to the regulation of digestion and secretion. This, however, requires modification when the morbid growths mechanically excite a considerable amount of inflammation, or even of local obstruction to the circulation.

We are not acquainted with any medical means whereby the alterations of vital properties in the molecules from which morbid growths take their rise, can be corrected. The same spontaneous power which places these growths beyond the controlling influence of the laws of textural nutrition, removes them also beyond the reach of general remedies. The surgeon can in some instances remove the part by the knife, and he can sometimes further modify the abnormal state by the direct application of escharotics or caustics, which are capable of destroying the morbid cells or germs which are the roots of the growth; and when this can be effectually done without serious injury to vital organs, the cure may be complete. Mechanical pressure carefully and steadily applied in such a way that it diminishes the supply of blood to the tumour without interrupting the circulation in other parts, has sometimes been efficacious in restraining the increase, and

even in promoting the absorption of morbid growths. It is doubtful whether the physician possesses the power to aid the surgeon in these cases, or to control the development of the mischief when it is beyond the reach of the surgeon's art, further than by promoting the general health of the frame.

In many instances, the secondary pathological changes induced by morbid growths, such as inflammation, congestion, dropsy, and flux, become the chief objects of treatment, and much benefit may then follow the employment of the usual remedies; this benefit is, however, commonly limited, both in extent and time, by the persistence and intractibility of the structural change that holds the position of cause. Thus where there is encysted dropsy of the ovarium, the accompanying peritonitis, ascites, œdema, obstruction of the intestines, and other secondary functional disturbances, generally admit of relief for a time; but as the ovarian tumour remains, and too often increases in spite of all treatment, these disorders recur again and again, and at last prove fatal. But the growth of the cysts themselves, although generally progressive, is occasionally very capricious—sometimes it is very rapid; in other instances, even under apparently the same circumstances, it remains stationary for many years. Nay, cases have occurred, although but rarely, where encysted tumours have altogether disappeared: particularly after the operation of tapping, or after spontaneous rupture into some of the cavities of the body. But such instances, although establishing a possibility that bears upon both prognosis and treatment, are nevertheless to be considered rather as exceptions to the rule that is more generally observed. There is more promise of success in the results already obtained from the practice of injecting ovarian cysts with a solution of iodine, which, even when used of considerable strength, causes very little irritation, and yet modifies the secretion and nutrition of the cyst.

SECTION IX.

MALIGNANT GROWTHS.

579. *Malignant growths* are distinctly organized structures, that appear in various situations in the body, and intrude their own particular substance upon the natural textures, often present-

ing themselves successively or simultaneously in different parts. There is perhaps no one character that is more indicative of malignancy than a tendency to pervade and penetrate the several constituent textures of a compound organ, and even to form attachments to neighbouring ones, so that all are united into one morbid mass: in this respect malignant growths are directly contrasted with non-malignant tumours and deposits, which push aside, compress, or distend the adjacent structures, but never penetrate into them. Malignant growths thus prove injurious, and eventually fatal, not merely by their bulk and position (§ 569), but also by the structural change which they induce in vital organs: by the intractable ulcerations and fungous sores to which they lead; and, lastly, by the wasting they produce, and by the deleterious influence they exert over the entire functions of the frame. In all these points, malignant growths exhibit a character that is perfectly distinct from that of the more simple, harmless growths, hitherto described; but it must be observed, that the degree of malignancy varies very much in different cases, one or more of the specified characteristics being absent, or but imperfectly developed; and that consequently, morbid growths or tumours are occasionally met with, holding a sort of uncertain and intermediate position between the non-malignant and the malignant.

580. The names *cancer* and *carcinoma* (conferred in consequence of a fancied resemblance of the diseased structure to the form of a crab, *cancer*, καρκινος,—which suggests the apt image of numerous claws penetrating and attacking adjacent parts,) have been long applied to the whole genus of malignant growths, comprising the following specific varieties:—*Scirrhus; mammary, pancreatic, and solanoid sarcoma; encephaloid or medullary sarcoma; fungus hæmatodes; colloid or gelatinous and epithelial cancer.* That these are all really but modifications of the same disease may be inferred from the fact, that they more or less resemble each other in the general characters of malignancy alluded to above; and that they frequently occur in the same subject, either simultaneously in different parts, or successively in the same part. Thus persons who have long been affected with scirrhus of the breast, often die with medullary sarcoma in the liver or lungs; or after a scirrhous tumour has been removed from some external part, an encephaloid or fungous affection is developed in its place.

The diversities may, for the most part, be traced to different degrees of activity in the *specific* or *cancerous matter*, which is the *materies morbi*, and to the varied effects which this matter produces in the implicated textures, accordingly as it is more or less intense and energetic. Of all these varied forms, it may be said generally, that scirrhus, and perhaps the mammary and pancreatic sarcoma, exhibit the most *chronic* character, and the least activity and tendency to increase locally, or to spread through the system; whilst the rest (except the epithelial) are more acute, cause more rapid growth in the parts first affected, and appear more speedily in other parts of the body.

581. The matter of cancer has a distinct and peculiar structure; it consists of nucleated cells and molecules, contained within an areolar or fibrous web of very uncertain density. Of these constituents the cells must be considered the most important; although they vary somewhat in form, they are present in every modification of cancerous growth. They are generally globular, and retain that shape throughout in the soft gelatinous affection; but in other varieties, some of them are caudate or spindle-shaped, as if they were about to be transformed into fibres. In scirrhus, and other more solid and chronic forms of cancer, the fibrous constituent of the structure is more abundant, so that it is even perceptible to the naked eye, as glistening striæ or bands of cartilaginous hardness, radiating through the mass; the cancer cells, and numerous granules, are seen between these fibres, and accompany them to their outermost extremities. In the cerebriform or medullary kind of cancer, the nucleated vesicles are in great numbers; and they are contained in cellular substance, which is well supplied with vessels. This is the variety in which the growth is most rapid, and in which sometimes a bloody tinge is given to parts, in consequence of the extravasation of blood in the loose new texture, whence the name *fungus hæmatodes*.

582. The intrinsic disposition to grow, often at the expense of nutriment that should be given to other parts of the body, which has been mentioned as a property of some formations not distinctly malignant (§ 574), is exhibited in a much more marked degree in malignant structures, the increase of which may take place most rapidly when all the natural textures are wasting away. This fact, again, suggests the idea of there being an independent vitality in these morbid growths, in virtue of which, parasitic-like, they

flourish luxuriantly, to the detriment of the rest of the frame. The question hence naturally arises,—Are these growths truly parasites, developed from ova or seeds introduced into the body from without, and, after entering it, and finding a proper nidus or soil, taking root or maturing as distinct organisms, after the manner of worms or hydatids, and drawing their nourishment from the surrounding fluids and solids? If it be objected to this, that malignant growths are too closely attached to, and too much identified with, the natural textures of the body to permit the notion to be entertained that they have a distinctness of being, it may be replied, that the cancer cells, their most characteristic portion, are often loose and unattached: these propagate themselves by the production of young cells in their interior cavities, and by means of these cell-broods are disseminated, first in contiguous parts, to which they appear to attach themselves; and subsequently, through the general channels of the circulation, which, in extensive forms of the disease, have been found to contain cancerous masses. An experiment made by Professor Langenbeck was supposed to have proved that cancerous pulp containing cells is capable of communicating the disease to animals on being injected into their veins, but the attempt to effect this purpose has since been frequently made by other pathologists without a like result. If such an experiment could be made to succeed, it would cause cancer to rank with contagious disorders, such as have been already named as having a possible connexion with parasitic origin (§ 99). Contagion is not, however, a common cause of cancer; the only unquestionable example ever adduced to prove it so, being the rare one of the penis having been infected by a carcinomatous os uteri. It has also been pertinently remarked, by Dr. W. Budd,* that the causes which seem to be most influential in inducing cancer are not such as can, in any intelligible way, favour the introduction of germs from without the body. Thus, in chimney-sweeps and others, the continued application of soot has been observed to be followed by the occurrence of cancer in the scrotum in so many cases, as to justify the inference that it was the exciting cause of the mischief. The often-repeated contact of a tobacco-pipe with the lip has also been frequently the precursor of cancer in that part.

The only alternative that remains is the assumption already stated—that cancer arises from a peculiar perversion of the natural

* Remarks on the Pathology and Causes of Cancer, *Lancet*, May 28, 1842.

nutritive process, in some degree analogous to such as has been already referred to when alluding to other kinds of morbid growth; but in the case of the malignant disease, the perversion is much greater in degree, and shows itself such not only in the origin, but also in the whole history of the affection. It can easily be conceived that causes acting for a long time locally, as, for instance, the application of soot to the scrotum of chimney-sweepers, of the tobacco-pipe to the lips of inveterate smokers, of irritations to the stomach in habitual dyspepsia, and to the uterus in irregular menstruation, may induce this extraordinary alteration in the molecular nutrition of these parts; but the peculiarity of the alteration is by no means explained by the conception. In other words, if it is assumed that cancer cells are modifications of the natural cell germs out of which textures are produced, the anomaly of the independent vital properties and growth of these modified cells, obviously so different from those of texture cells in general, and so destructive in consequence of this difference, is no further accounted for, or referred to a sufficient cause, by the assumption. Indeed, it remains for future investigation to establish the law of this difference. It has been stated that Dr. Hodgkin has proposed an ingenious hypothesis to account for these and other morbid growths,—namely, that they originate in cysts (not cells or microscopic cysts, but larger vesicles comprising these): and that the multiplication of these cysts within each other,—their prolongation into radiated fibres,—their pressure on adjoining textures,—and the inflammation, induration, ulceration, atrophy, or gangrene consequent in these textures, constitute their entire history. What appears to me to be chiefly wanting to establish Dr. Hodgkin's views is, a more distinct demonstration of the existence of the alleged cysts, for, if present, they ought to be distinctly visible at the outer limits of cancerous growths during their extension.

There is one point in the physical history of cancer that is of considerable interest both in a physiological and in a pathological sense. Cancerous growths result from perverted nutrition, but this perversion is of a distinctly different kind from degradation, such as is presented in tubercle. In tubercle, that which ought to be organized is not organized, and is, on this account, incapacitated for becoming a part of the living frame. In cancer, the matter is organized and made alive too; but it is organized and vitalized in the wrong way, and is, on that account, unfitted for

its usual employments. The force that ought to be thrown into the *development* of the individual cells, so that they might be altered for structural adaptation, is thrown into their multiplication and reproduction. Hence the cell germs remain little else but cell germs, and are loosely connected together, and multiply with extreme rapidity, brood after brood, instead of being matured into elaborated tissue-cells, and being then firmly attached together, and fabricated into texture. The perversion seems to be one of turning development into crude multiplying energy, instead of being one of degradation, that is, of arrest, or retrogradation of development. Hence, cancer and scrofula rarely show themselves together in the same subject, although it is, of course, possible that circumstances may change the one form of perversion into the other, and that scrofulous persons may cease to be scrofulous, and may become cancerous, or the converse. Hence, too, the treatment that is appropriate for the one, is, to a certain extent, inappropriate for the other.

As regards the microscopic diagnosis of cancer, it is often very difficult and uncertain. The caudate cells and the fibrous stroma are very characteristic; but epithelial cells are frequently so like to the former as to be hardly distinguishable from them, especially when they are young pavement cells. The microscope detects in cancerous substances, molecules and amorphous granules, nuclei, cells of different sizes and forms, filamentous fibres, crystalline matters, and exuded blood corpuscles. In fact, it is primarily a granular exudation, which is secondarily converted into cells and fibres, which form an interlacing stroma. It will often aid the diagnosis to bear in mind that epithelial cells are pretty uniform in size, and exhibit a disposition to run together in groups, and adhere by their edges; while cancer cells are mostly distinct, and separated by interspersed granules and molecules, and are very diversified in dimensions. It is only where the distinct caudate cells of varying size, interspersed with granular molecules and with fibrous stroma, *all co-exist*, and there are suspicious general symptoms also, that the case can be considered to be beyond all doubt.

583. But however uncertain the question of precise origin may be, there are some highly important practical facts already gleaned concerning the nature of cancerous growths. Microscopic examination, as well as the general history, pretty clearly shows that they begin in limited localities; that they extend by the endo-

genous and nuclear multiplication of their cells, which arrests the nutrition of the adjacent textures, and diverts the material that ought to be devoted to that, to effect the growth of the tumour; that they ultimately infect other parts of the body, by sending their nuclear germs to the nearest lymphatic glands, and by mixing them with the circulating blood (§ 259), whose streams then convey them to the liver, lungs, and other vascular parts, and so induce independent formations there, much in the same way as scattered purulent deposits are caused, when the blood is infected with pus (§ 470). Sometimes the cancerous matter is found in clots within blood-vessels, and in the coagulable lymph effused by inflammation.*

But the history of malignant growths comprises not only the phenomena of their development in different degrees and forms, but also their effects on the adjacent textures; and it seems to me to be possible, by a due consideration of both these classes of circumstance, to arrive at a better comprehension of many of the modifications which cancerous structures present. Scirrhus, the slowest form of the disease, generally occurs in persons above the age of forty, in whom the textural nutrition is sluggish, and in whom the cancerous matter is very gradually developed in consequence; the effect on the adjacent textures is then to excite inflammation of a chronic kind, and therefore leading to induration, often to contraction also (§ 479), and more or less to obliteration of the natural textures. Hence the hard, knotty, corrugated swelling of scirrhus of the mamma, rectum, pylorus, &c., commonly attended with more or less pain of a peculiar stinging or lancinating character, besides various functional disturbances (obstruction to the passage of food or fæces, severe dyspepsia, vomiting, &c.) The persistence of irritation in the indurated parts leads (as a matter of course) to ulceration (§ 466). This constitutes what is called *open cancer*, with ragged, inverted, or everted edges, and a fungous or sloughy interior, that discharges dark, offensive, ichorous matter. That such ulcers should be wholly incapable of healing is quite intelligible, when it is remembered that the walls are really composed of the cancerous structure and of the compressed

* In a case (which I saw with the late Mr. Avery) of malignant disease of the lungs and deep cervical glands, involving the 8th nerves, there had been recent pleurisy, and the bands of false membrane were glistening, and grated under the scalpel from the presence of cancerous fibres.

remains of the natural textures, which have become too poor and too much perverted to afford euplastic exudation. The ulcer often is an outlet for the increasing cancerous matter; so that if its discharge be checked by external means, the disease is the more likely to spread elsewhere, or to attack other parts: as the ulceration destroys the indurated mass, and so removes the barrier that has been temporarily erected between the cancerous germs and the healthy textures, there is a greater chance of the body becoming more generally infected. Hence, too, from the multiplication and diffusion of the germs, secondary malignant growths may appear in other parts, and are commonly of the softer and more rapidly growing kinds. The influence of scirrhous cancer on the general frame is carried to a greater degree than that of any other form, perhaps on account of its slow progress. Emaciation sometimes reaches a point unequalled in any other disease; and the wasting affects the composition, as well as the bulk of organs and textures. Thus bones lose a considerable portion of their animal matter, and become so brittle, as sometimes to be fractured by the slightest violence. The membranes become extremely thin; the omentum often wastes away, excepting a few threads. The lungs exhibit a remarkable lightness in weight and colour; and I have seen the old cicatrices, or consolidations, so frequently found at their summits, reduced until almost as pliant as other parts of the pulmonary texture.* But nothing is more remarkable than the ex-sanguine state of the textures generally in cancerous subjects. This condition is obvious during life in an extreme pallidity, often associated with a sallowness or peculiar lemon-tint of complexion.

* It appears to me possible that the rare co-existence of tubercle with cancer, noticed by some writers, may be due to the former being removed by absorption, during the extraordinary wasting of textures which attends chronic cancer. I have twice found, in the bodies of persons who died of cancer, considerable remains of tuberculous deposit at the apex of the lungs, without any tubercles in other parts. In one case, masses, partly caseous, partly calcareous, of the sizes of a pullet's and a pigeon's egg, were thus encysted in a thin membrane. In another, there was a cavity in the middle lobe, communicating with the bronchi, and traversed by a band of dense tissue, resembling that common in tuberculous cavities, and also lined by a thin, smooth membrane. In all these cases, the other parts of the lungs were free from tubercles. Now, it does not appear probable that such considerable tuberculous deposit should have taken place without there having been some in other parts also. Recent tubercle is not met with thus limited to one portion of the lung. These and similar facts connected with the emaciation of old age, seem to me to furnish additional arguments in favour of the possibility of absorption of tubercles (§ 561.) For cases of co-existence of Cancer and Tubercle, see Pathol. Trans., vol. iii. pp. 254 and 258; vol. iv. pp. 35 and 102.

Scirrhus chiefly occurs after the age of forty; and the more advanced the age, the slower generally is the progress of the cancerous disease. It has been remarked by Sir Charles Bell, Sir Astley Cooper, Mr. Travers, and others, that scirrhus of the breast runs a comparatively rapid course at the age of forty-five, but often remains stationary for years, and hardly appears to shorten life at the age of sixty or seventy. This shows the share which activity of textural nutrition has in causing the increase and dissemination of cancerous disease. It is under such circumstances that operations for the removal of the morbid growth have been most commonly successful; but it must be remembered, also, that in such cases they are less strongly called for.

There is one form of cancer which involves in itself certain very interesting peculiarities on account of the bearing these have upon the histological nature of malignant growth. This form invariably commences either in the skin, or in mucous membrane, and the diseased formation almost entirely consists of flattened cells very nearly resembling epithelium scales,—hence the variety is termed *epithelial*. It generally commences in some spot that has been exposed to irritation for a long time, and progresses very slowly, and it rarely extends to any parts beyond the nearest lymphatic glands. It is but little prone to assume the malignant type, and does not often return after extirpation. The substance, when examined by the microscope, is found to consist of layer upon layer of the peculiar compressed cells, some, however, either newly formed, or swollen by the imbibition of moisture, and round, oval, or even fusiform. When the neighbouring glands are affected, their substance becomes exactly of the same kind. The cells have just the same epithelial aspect. Now, what is mainly interesting in this variety of cancer is, that in different cases every possible shade is found between mere simple hypertrophy from multiplication of the epidermic or epithelial cells under irritation, to the formation of unquestionable cancerous germs. It is often quite impossible, in aged subjects, to determine whether small excrescences of the skin are mere warts or of a cancerous nature. All this points to modifications of the normal operations of cell vitality—a perversity which causes the individual vesicles to multiply their germs, instead of ripening and maturing themselves—as the most probable cause of the diseased development. When the vesicles are produced more rapidly than they ought to be, but are still tolerably perfected in their own

intrinsic structure, they constitute little more than hypertrophied epidermis, or warts. But in proportion as more and more of the immature and over active cell-germs are mingled with the matured scales, the growth tends towards malignancy of character. It will be observed, then, that this epithelial variety of the disease is really *scirrhus*, occurring in the outer integuments of the body where the change can be most readily examined, and in its least noxious form.

584. The *pancreatic, mammary, lardaceous*, (or pork-like,) and *solanoid*, (or potato-like,) varieties of cancer appear to be intermediate between scirrhus and encephaloid disease, increasing more rapidly than the former, and yet somewhat resembling it in firmness. They are attended with comparatively little pain, on account of the smaller degree of tension and induration which they cause in the textures implicated. For the same reason they are less disposed to ulcerate (§ 466) or slough than other forms (§ 474); they commonly prove fatal, either by encroaching on some vital part, or by causing the dissemination of cancerous deposits in other parts of the system.

585. *Encephaloid*, (brain-like,) or *medullary sarcoma*, is the most acute or rapid variety of cancerous growth. It occurs chiefly in young and middle-aged subjects, and the most vascular textures; and its peculiarity may fairly be connected with activity of molecular nutrition. This probably is the cause of the quick multiplication of the cancer-germs or cells (viewed as mere modifications of the ordinary cell-germs of the textures); and their elongation and growth into large caudate vesicles, and the more or less branching fibres, that form the stroma or web of the growth; but much of the speedy increase and early dissemination of this variety of cancerous disease, may also be attributed to an active formation of plastic matter, which the presence of the cancerous substance excites in the vascular structures. The mass of encephaloid tumours comprises false membranes, lymph, and even coagula of blood, in various degrees of organization: mingled with these are the peculiar cells and fibres which luxuriate in so fertile a soil. It is in connexion with tumours of this kind that the fact already mentioned has been observed, namely, that coagula in veins near the affected part have exhibited the encephaloid appearance. Coagulable lymph, produced by inflammation of serous membranes or of the parenchymata of organs, has done the same thing. The

speedily destructive influence of this kind of cancer is mainly to be ascribed to the rapid dissemination of the cancerous matter, and the bulky deposition which it induces around it, which, although organized, and highly vascular, is beyond the controlling influence of the powers of assimilation or absorption, and consequently obstructs or compresses adjacent organs to a fatal extent. The facility of growth in these tumours receives some explanation from the varicose condition ascertained by Mr. Kiernan to be present in their vessels, and from their free communication with arteries (§ 420), as pointed out by Schroeder Van der Kolk. The same circumstance, taken in connexion with the general softness and looseness of their texture, accounts also for the facility with which hæmorrhage takes place into their substance (§ 357), causing the appearance that has led to the use of the term *fungus hæmatodes*. These forms of disease commonly prove fatal before the emaciating effects, so remarkable in scirrhus, have advanced far.

586. The *colloid* or *gelatinous* variety (*areolar* of Cruveilhier) seems to me to present the cancerous element almost in a separate state, and but little mixed with natural tissues or their products. According to Müller, it consists chiefly of cells contained in a very slight loose web; the cells are larger and rounder than usual, and contain small cells, which also enclose cell-germs. The peculiar germinal principle of cancer is here, therefore, very abundant and prolific; but the nutritive secretion of the surrounding textures is not equally copious: no distinct growths, therefore, are formed; but the gelatinous matter is infiltrated into other textures, and this chiefly in connexion with advanced stages of other forms of the disease.

Additional varieties of cancer have been described, by Dr. Carswell and others, as characterized by particular forms in the growth, and under the names of the *tuberiform, stratiform, ramiform*, &c. But these are all probably dependent merely on the anatomical character of the parts in which they appear, and on the extent and rapidity of development.*

587. Another morbid production that has generally been classed

* Many interesting particulars respecting the microscopic characters of the varieties of cancer will be found in the works of Lebert, Virchow, Hughes Bennett, Rokitansky, and Paget. To the last-named author, in the second volume of his "Lectures on Surgical Pathology," I would particularly refer the reader for a masterly exposition of the distinctive characters and relations of the several forms of cancerous disease.

among malignant growths, because it affects many textures and sometimes supersedes them, is *melanosis, black cancer,* or *black tubercle.* It most commonly occurs in the form of a loose cellular texture filled with peculiar black matter suspended in a serous liquid; but sometimes its substance is quite compact, and in consistence resembles crude yellow tubercle, or the lardaceous variety of cancer. I have a drawing made from a lung, which exhibits a combination of encephaloid with melanotic substance, the latter of compact texture, like the nodules of pulmonary apoplexy, and varying in colour from a dark bistre brown to a deep jet-black. A similar combination has also been noticed by Cruveilhier and Carswell. Andral describes melanosis as occurring in four forms: —(1) It pretty frequently constitutes masses, encysted or otherwise; (2) the matter which composes it may, like the tubercular matter, be infiltrated into different tissues; (3) it may be spread like a layer, of greater or less thickness, on the free surface of membranous organs; (4) it may exist in the fluid state, either pure or mixed with other fluids."*

The one characteristic of all these forms is the presence of a peculiar black matter, which, from the analyses of Dr. Fyfe, M. Thenard, and M. Foy, appears to be a highly carbonized insoluble matter, very much like altered colouring principle of the blood. It has been compared by Andral to the black pigment of the eye, and he considers it to be identical with the black deposit commonly found in the lungs and bronchial glands. The colouring principle of the blood certainly is sometimes changed into a perfectly black matter, as instanced in the dark vascular striæ and patches that occur in the intestinal canal, particularly after chronic inflammation, where the blood has been effused, or retained in the vessels, and altered in its physical characters by the influence of the secretions and gases. These black appearances are called by Dr. Carswell spurious melanosis. The black pulmonary matter is clearly a carbonaceous powder stored away in the interstices of the textures, and sometimes in the vessels and bronchial glands; but whether it is the colouring matter of the blood in an altered state, or an independent deposit of carbon, is not certainly known. All that is requisite to convert the colouring principle of the blood into a black carbonaceous deposit is abstraction of a certain amount of hydrogen, which the mineral acids are capable of

* "Pathological Anatomy," (Transl.,) vol. i. p. 249.

effecting; it seems to be far from improbable that a change of this nature takes place naturally where black pigment is formed by the agency of peculiar cells (pigment cells), and as a result of disease in melanosis.

But this production of black matter may co-exist with different modifications of the nutritive process; it may be associated with plastic substance, as instanced in cellular and membranous melanose tumours; with cacoplastic, as seen in hard black tubercle, and in the black consolidations of chronic pneumonia; or with aplastic, as in the peculiar combination of black with opaque caseous matter, not unfrequently found in the lungs and bronchial glands. So, too, it may be, as previously stated, combined with various forms of malignant disease; but I am inclined, with Andral, not to class simple melanosis with malignant growths. Mr. Paget says that melanotic cancers may have the general characters of any of the varieties of medullary cancer, but owe their distinctive feature to the presence of numerous pigment granules, not unlike the pigment cells of the choroid membrane, and in the rete mucosum of coloured skins. They show a remarkable proneness to originate in the dark moles or pigmentary nævi which frequently occur in the skin, especially in advancing age.*

588. The *treatment* of malignant disease has been mostly considered to belong rather to the province of surgery than to that of medicine; the removal of malignant growths by operation has nevertheless not been generally advised by surgeons down to the

* Lectures on Surgical Pathology, vol. ii., p. 490.

I take this opportunity of remarking that the formation of black or pigmentary matter, both in health and in disease, is a subject which deserves fuller investigation than it has received. The readiness with which exposure to the rays of a hot sun, and the action of blisters and other irritants cause a deposit of pigment in some skins, is worthy of notice. But in some obscure cases this pigmentary deposit in the skin takes place abundantly without any assignable cause. Such cases have recently been described by Dr. Addison and others, under the title of *bronzing of the skin*; and the physician just named conceives that he has traced a connexion between this affection and diseased conditions of the supra-renal capsules. I was recently consulted by a lady whose complexion had changed in two years from comparatively fair to the hue of a mulatto; the parts most exposed to the light being, as usual, the darkest. This patient had resided in a malarious district, and her blood was obviously deficient in its due proportion of red particles. This and other facts suggest the notion that this black pigment, as in the case of the simpler kinds of melanosis, may arise from a degeneration of the red corpuscles of the blood, which then become deposited in the situations where they occur naturally in the negro.

present time. There is much, however, to be deduced from the investigations of physicians touching the matter, when and why operations may be expected to be successful. The indications of treatment which are suggested by the foregoing account of malignant disease may be summed up under three heads:—(1) to extirpate the malignant growth; (2) to retard its development; and (3) to counteract its effects.

The complete extirpation of malignant growths can be effected only when they are quite local, so that after their removal by the knife or by caustic, no root or stray germs shall be left behind. Reasons have been advanced for the supposition that cancer is strictly local at first, and that if it be completely excised at an early period, permanent cure may result. But to ensure this success, it is essential that every cancerous cell be removed; and Dr. Hodgkin has recommended that careful examination of the tumour should be made immediately after its excision, to see that there is no aggregation of cancerous cells on the cut surface. These may be detected even by the naked eye if present. Dr. W. Budd advises that the microscope should be employed for the same purpose: "If the characteristic cells were found on the cut surface of the portion removed, it would be morally certain that others have been left behind, and that the extirpation is incomplete, although, on the other hand, the absence of these cells would be by no means so sure a guarantee of their entire removal. Such an examination would, however, always be a matter of great interest to the surgeon."* The best chance of security is afforded by the operation being performed before the constitution has been in any degree affected by the disease, and before any neighbouring parts, especially lymphatic glands, have given tokens of infection. There is therefore most reason to entertain hope for a successful issue when the growth is chronic, inactive, and of small extent, as it is apt to be in scirrhus of the lip, skin, or breast. In a general way, the chance of cure from the removal of a part affected by cancer is in inverse ratio to the rate at which the growth has been developed—for this rate measures the force of the malignant diathesis. If any cancerous texture or germs are left behind, the operation is likely to do harm instead of good, by exciting them into increased activity, and by so developing the acute form of the disease. Instances have occurred in which a cancerous

* *Lancet*, May, 1842.

breast has been spontaneously removed by sloughing; such events are, however, unfortunately very rare. Cauterization is less advisable than excision, because it is less manageable.

589. The second indication—to retard the development of the malignant growths—has chiefly been attempted by the employment of measures which tend to diminish the circulation through the diseased part. Repeated local bleedings have been found useful, partly perhaps on this account, and partly by relieving the inflammation that is excited by the growth. One valuable auxiliary that acts somewhat in the same way, and that has long found many advocates, is the application of pressure. Such an amount of pressure as will reduce the circulation through the part to the lowest degree compatible with its life will be tolerably sure to arrest the increase of any morbid growth, by depriving it of its nutrition. But for the success of this measure, it is no less necessary that the disease shall not have extended to other parts besides those to which the pressure is applied, or the growth will certainly proceed, in those parts, which are commonly internal ones, with a rapidity that is increased in proportion to the outward arrest. The best plan for applying pressure is that which has been suggested by Dr. Arnott—namely, the application of the slack air-cushion under a bandage. It is very doubtful whether medicine possesses any power of influencing malignant growths through the constitution. Various remedies have enjoyed an ephemeral repute for their efficacy in cancer. Of these, conium has been the greatest favourite. Dr. A. T. Thomson was of opinion that the iodide of arsenic has some controlling influence, and recently the choride of bromine has been recommended with the same object. But it is doubtful that any of these agents can do more than soothe irritation, and restrain such common inflammation with its results, as incidentally attends upon malignant growths.

590. The third indication to counteract the effects of morbid growths, is more commonly the object of treatment; but the means of fulfilling it fail more and more as the disease advances. The use of narcotics of every description, both general and local, for soothing the pain and irritation, and the employment of occasional local antiphlogistic measures to obviate inflammation and congestion, are sanctioned by experience as valuable palliations in malignant disease. Tonics and a nutritive diet may also prove serviceable by arresting cachexy and emaciation. They seem to

me to possess considerable efficacy in supporting the constitution, and supplying it with strength to resist the enemy that is preying on its vitals. Preparations of iron, when they are readily borne by the patient, prove to be the best tonics. The remarkable emaciation in cancerous disease appears to point to the cod-liver oil, as a nutritive remedy that might be expected to prove advantageous, but it seems to promote the growth of the diseased structure more than to nourish the body.

SECTION X.

DISORDERS OF MECHANISM.

591. Many diseases arise from derangements in the mechanism of organs, which are not included in the category of any of the conditions previously noticed. It would be altogether foreign to the purpose of the work, to enter in detail into the consideration of these. But to complete the general outline, it may suffice to specify the following examples.

Dilatation.—Hollow organs are liable to be distended, in consequence of undue accumulation of matter within them, and this distension may become permanent dilatation of their cavities, if it be long continued or frequently repeated. The heart, the arteries and veins, the air cells of the lungs, the bladder, and portions of the intestinal tube, are the organs and structures most prone to be injured from this cause. The distension may be caused either by obstruction to the forward movement of the contents of the several organs, or in consequence of loss of propulsive power in their walls. Mechanical textures are apt to be overstretched and relaxed in consequence of a diminution of elasticity or natural cohesion in their molecular composition. Ligaments, tendons, and fasciæ sometimes become unfitted to perform their offices of binding and holding parts together in this way.

592. *Contraction.*—This is precisely opposite to dilatation. Its occurrence, as the result of disease, in the textures of organs and in serous membranes, has been frequently alluded to in the preceding pages. When it takes place in the membranes of tubular parts, it leads to stricture, and partial or entire obstruction of

the passage through them. It is apt to affect the intestines, the urinary and respiratory tubes, and the different vessels, in this way.

593. *Laceration.*—Living textures may be ruptured or torn either by direct violence, or in consequence of disease, and further structural derangements may be induced as a consequence. Rupture of the cardiac valves, of portions of blood-vessels and of air cells, is attended by this result. But lacerations of the walls of the heart or large arteries, of the stomach, of the gall bladder, and of the urinary bladder, are speedily followed by death.

594. *Displacements.*—Tumours and internal effusions are very apt both to compress the textures of organs, and to push them out of their proper situations. The heart and lungs are thrust upwards in the chest, and the various abdominal organs are forced out of their usual positions by ascites, ovarian dropsy, and enlargement of the liver. The parenchyma and air tubes of the lungs are compressed by an enlarged heart, and by an aneurismal tumour. Pleural effusion squeezes in the lung of the side on which it occurs, and effects displacements of the heart, mediastinum, diaphragm, liver, and walls of the chest.

595. *Contortion.*—The contortion of rigid parts is exemplified in rickets, mollities ossium, and rheumatic nodosities of the joints. Curvature of the spine changes the position of the ribs, and commonly deranges the mechanism of respiration in consequence; and when the deformity is very great, the functions of the heart, great arteries, and abdominal viscera, are also injuriously affected to a considerable extent.

CHAPTER V.

THE CLASSIFICATION, SYMPTOMS, AND DISTINCTION OF DISEASES.

SECTION I.

NOSOLOGY.

596. HAVING now considered the causes which produce disease, the manner in which those causes operate, the changes that are thereby produced both in function and structure, and the different remedial influences that can be brought to bear to obviate or correct these changes, it remains next to notice the sensible symptoms by which diseased conditions make their presence manifest, and the way in which these symptoms are varied and combined to constitute *special diseases*. It has been found convenient, in considering the wide range of subjects embraced by general pathology when reduced to the domains of actual disease, to group specific disorders into classes and orders, and to subdivide these into genera and species, characterizing the peculiarities of each by a definite description. This classification and descriptive definition of disease forms what is usually designated by the term *Nosology*.

597. Diseases have been classed in different ways. The first method that was attempted, professed to group them according to their most obvious phenomena or prominent symptoms. Of this character was the system of Sauvage, who distributed diseases into the ten classes:—*vitia, febres, phlegmasiæ, spasmi, anhelationes, debilitates, dolores, vesaniæ, fluxus, cachexiæ*. The classifications of Linnæus, Vogel, and Sagar, were also of the same artificial kind; and Cullen's method was a strained simplification of a similar plan, which pressed all diseases into one or other of the four classes—*pyrexiæ, neuroses, cachexiæ,* and *locales*.

The chief objection to this kind of arrangement, which may be called *symptomatic nosology*, is, that it regards symptoms as the essence of disease, whereas, in truth, many symptoms are not essential, and even those that occur most constantly are extremely variable, both in character and severity, and by no means uniformly express either the nature or the amount of the real derangement of function and structure. Similar symptoms, too, dependent upon the most diverse causes, are associated together, although they may require quite opposite plans of treatment; whilst diseases that are really kindred in their nature, are widely separated, because they differ in their symptoms. The artificial method of classification is admissible only as a provisional measure, capable of effecting a temporary and conventional arrangement of subjects, pending the investigation of their true nature; when this has been ascertained, or even as the investigation advances, the artificial method should give place to a more natural one, which is not a mere glossary of names, (or symptoms,) but is able in itself to express the most important bearings and facts that have been ascertained.

598. The appropriate foundation for a natural classification of diseases is accurate pathology, or knowledge of their intimate nature; but the subdivisions of the arrangement may be conveniently determined either by the situation of the derangement, or by some of its most prominent characters. The classification of Pinel proceeds upon this idea, although it is necessarily imperfect in consequence of the infant state of pathology at his period. His nosology comprised five classes:—*fevers, inflammations, hæmorrhages, neuroses, and organic affections.*

Pathology may be applied to the classification of disease in two modes. It may be made the first step in the arrangement, the several disorders being distributed in classes according to the particular pathological conditions affecting the systems defined by general anatomy. Thus, in accordance with the pathological principles that have been passed in review in the previous pages, the *classes* might be—diseases of the muscular system, of the nervous system, of the secernent system, of the blood, of the vascular system, and of nutrition. The subdivision of these classes into *orders* might then be determined by the constituent pathological elements present; thus, diseases of the muscular system would group themselves into those of irritability and those of tonicity; the *generic* subdivision of these would be fixed by the

excess, the defect, or the perversion of those properties; and, lastly, the *specific* distinctions would depend upon the organ or locality affected. This arrangement, however, is not suitable for clinical or practical purposes, because diseases are generally too complex to admit of being easily resolved into their elements: they commonly comprise several elementary pathological states, and the relations of these states vary with the progress of the case.

599. The other mode of applying pathology to nosological arrangement, is to cause it to furnish such distinctions of divisions and subdivisions as may be useful in matters of diagnosis and treatment, whilst the remaining divisions are based upon the situation of the disease or other circumstances. Thus, as *classes* we may have, diseases of the *organs of respiration;* of the *organs of circulation;* of the *apparatus of alimentation;* of that of *urinary excretion and of generation;* of the *nervous system;* of the *organs of locomotion;* of the *skin;* of the *blood;* and lastly, *general diseases,* having no defined seat. The subdivision of these classes into *orders* may then be founded on pathology: thus, each class may be made to comprehend *functional* diseases, subdivided into disorders of *irritability, tonicity, sensibility,* &c., and *secretion; inflammatory* and *congestive* diseases; and diseases of *nutrition* (*structural*). A further division into *genera* and *species* may be made according to the anatomy of the parts: thus, of the class, *diseases of the organs of respiration*—order, *functional disorders;* one species would be *spasm* and *paralysis of the larynx,* another, *of the bronchi,* &c. But in general diseases, the subdivisions too must be altogether pathological, or founded on causes or symptoms: thus, *fevers* are distinguished into *inflammatory, eruptive, adynamic, contagious, malarious* or *intermittent,* and *continued,* as one or the other of these characteristics becomes most available.

This last kind of classification, although it may be less precise and methodical than the others, is the most useful in practice, because it most closely follows nature, and, overlooking more minute and difficult distinctions, leads the attention at once to the seat and nature of the disease, and so renders available those general principles in pathology and therapeutics, which form the foundation of rational medicine. Another great recommendation in this kind of nosology is, that whilst it includes all diseases hitherto distinguished, it also points out others, which may and do occur, but which, for want of distinct pathological views, have

been commonly confounded with such as are more prominently expressed.

600. The *definitions* by which individual diseases are designated may refer either to the pathological nature of the disease, or to its characteristic symptoms, or to both; and in some instances, the causes or results of the disease form essential portions of its history. It should always be remembered that the great purpose of nosology is to arrange and define diseases in such a manner that the true nature of each, and the chief points of affinity and difference by which they are associated or contrasted, may be succinctly and obviously expressed; and whether these points of affinity or difference are most manifest in the causes, nature, or symptoms of the diseases, the arrangement and definition should alike mainly take cognizance of them. Thus, in addition to its leading peculiar symptoms, the definition of a distinctly infectious disease, such as scarlatina, should express its infectious character; that of a disease indubitably caused by marsh miasmata, such as ague, should state this fact; then both being classed as *general* diseases, and in the order *fevers*, the one of the genus *eruptive*, the other of the genus *intermittent*, a great deal of their intrinsic nature, as well as of their distinguishing characters, will have been set forth by the mere indication of their nosological position. The further the knowledge of pathology is advanced, the more considerable part it must take in nosological systems; but in the meantime it is expedient to render classification and definition as useful as possible, by deriving them from *all* the most available sources, rather than to keep them more precise and less applicable until science is sufficiently advanced to supply a system that is faultless in every point.

As this work does not profess to enter upon *special pathology*, or the history of individual diseases, it is unnecessary to proceed into details of nosology. The foregoing remarks are intended merely to explain the objects of classification, and to introduce the two associated subjects, *semeiology* and *diagnosis*.

SECTION II.

SEMEIOLOGY AND DIAGNOSIS.

601. *Semeiology* treats of *signs*,* and, in a medical acceptation, of the *signs of disease*. The word *symptom* is commonly used by physicians in the same sense as *sign*; but, as its etymology implies,† it is really a more vague expression, signifying *coincidence* or *co-occurrence* rather than a direct or constant connexion. Some writers (especially among the French), have proposed to restrict the word symptom to phenomena manifested by present disease only; but this is contrary to the usual custom, which warrants allusion to *precursory* and *consecutive symptoms*, *symptoms of health*, &c. Some again have confined the term *symptom* to phenomena that are connected with vital properties, and have designated such other phenomena as are more directly physical, as *signs*. This was the sense in which Laennec employed these terms, and others have followed his example. Although this acceptation of the words is not in strict accordance with former usage, or with their etymology, it is yet conventionally convenient; but it is as well to render their meaning more precise by prefixing the epithets *vital* and *physical*, as was first suggested by Bayle, and partially adopted by Laennec.

Let then the word *sign*, employed in relation to disease, be generally understood to imply anything by which the presence of the disordered condition is made known. And let *symptom* express any phenomenon which becomes obvious in the course of disease: a symptom may often prove to be a sign; but many symptoms are of such uncertain connexion with a particular disease, that they cannot be said to indicate its presence, and therefore they cannot be called signs. The more precise designations of *physical signs* and *vital symptoms* serve to attach a more distinct meaning to the different phenomena of disease; and therefore a brief statement of the grounds of the distinction, and of the proper application of the terms, will help to indicate the respective values of the classes of phenomena to which they appropriately belong.

* "*Sign*, that by which anything is known."—Johnson's Dictionary.

† Συμπτωμα, from συν, with, and πιπτω or πτοω, to fall.

602. *Physical signs* are certain material properties of the body, or of its constituent organs and textures, which are perceptible to some or other of the senses of the observer. Thus, the form, size, colour, firmness, softness, weight, heat, and odour, of the entire body, may be said to afford physical signs or evidence of its condition, whether in health or in disease. So, also, the form, size, colour, resistance, position, temperature, smell, and acoustic properties of any part of the body, afford physical signs of its condition, whether in health or in disease. Thus it is that the appearance of external deformity or structural alteration, the feeling of a solid tumour, or of the fluctuation of liquid in the abdomen, and the listening to abnormal sounds, produced by or in internal parts, furnish physical signs of the presence of disease.

The discrimination of the difference between the signs of health and those of disease implies an exact knowledge of what is usual in health; and this knowledge is derived (1) from general observation and experience of healthy standards, (2) from anatomical and physiological comprehension of what the phenomena of health ought to be; or (3) from an acquaintance with the particular standard of health in any individual case.

All of these standards are available in instituting a comparison; the first is less exact than the other two; but it is often of considerable service nevertheless. Thus, a jaundiced hue of the body, extreme pallor or great emaciation, are physical signs of disease which even the casual observer cannot mistake. But slighter degrees of the same states may be obvious only to those who, through previous acquaintance, know more exactly the standard of health in the individual, and can therefore detect the most trifling departure from that standard. Again, in local disease: a large tumour or swelling in any part is a sign of disease that is manifest to every one; but a smaller or more deep-seated tumour may be discovered only by those who have an accurate knowledge of the healthy anatomy of the part, or by those who have previously made themselves familiar with the shape and feel of the part in health.

603. Another means by which the physical signs of disease may be distinguished from those of health is through a comparison of parts that are naturally symmetrical. Thus, a slight swelling in one limb may be readily discovered if it be compared with the corresponding part of the opposite limb. A projection or contrac-

tion of one side of the chest will commonly escape observation until the two sides are compared by inspection or by measurement, but the difference will then be at once apparent. This method of symmetrical comparison is applicable, not only to all external parts and organs, but also to some internal parts, which, although not strictly symmetrical in themselves, are yet so far equally distributed on the two sides of the body as to give symmetry to its exterior. Thus, the lungs, in health, are placed so equally on both sides of the chest, that they give corresponding motion and acoustic properties to each; and percussion and respiration yield similar signs on either side. When therefore disease affects one side, it modifies its physical signs, and the difference becomes obvious by comparison with the signs of the healthy side. A certain degree of uniformity also attains in the position of the viscera in the abdomen, so that (making allowance for the greater bulk of the liver on the right side) any considerable difference in the shape or resistance of the two sides may be interpreted to be a sign of disease.

604. Where organs are concerned which are not symmetrically placed, a previous acquaintance with the natural structure, position, and physical properties, is necessary. Thus, the physical signs of diseases of the heart and liver, cannot be recognised, unless there is some healthy standard with which to compare them. This standard is soon supplied by careful observation of the signs in health; and an intimate familiarity with anatomy and physiology, which teach the healthy condition and functions of the body, assists greatly in establishing the groundwork for reference. Thus anatomy shows that the heart lies naturally behind the lower half of the sternum, and the adjoining parts of the cartilages of the left ribs from the third to the sixth; and physiology points out that its regular double sound should be heard in this region: here then is a healthy standard, and when a case is compared with this in which the impulse of the heart is felt to beat over a much wider space, and the sounds are irregular and masked by grating or blowing murmurs, these phenomena are at once felt to be signs of disease. Again, anatomy teaches that the liver in a healthy adult extends little, if at all, below the margins of the ribs on the right side; and this fact makes it an unmistakeable sign of disease when there is dullness on percussion, and resistance to pressure, below these ribs, for this proves that the liver is reaching consi-

derably below its usual situation. The knowledge of the healthy mechanism and functions of the apparatus of respiration, circulation, digestion, and excretion, is in many respects necessary to enable us to distinguish the signs of disease from those of health: it will guide us to refer signs to their true causes; and indeed often suggests the particular signs which may be expected to arise in particular lesions.

605. Physical signs are phenomena taking place in the body, in accordance with certain physical laws. It is therefore obvious, that an acquaintance with those laws, as well as with the mere mechanism of the body, must assist in the correct interpretation of the phenomena, and serve to explain of what they are signs, how they are caused, the variations which they may present, and the best mode of appreciating them. Thus an aneurism of the arch of the aorta may be detected and chiefly studied through the physical signs which it produces. It forms a tumour under or near the top of the sternum, pulsating in a distinct manner, and with a peculiar sound; this tumour may press on the air-tubes in such a way as to alter their shape, and by partially obstructing the passage of the air through them, may also change the sound of breathing in the spot: a similar pressure upon the veins may also throw their current into unusual sonorous vibration; or through more complete obstruction, it may cause them to swell in a remarkable manner above the tumour: the aneurism, as it enlarges, also encroaches on the lungs, the walls of the chest, the muscles, nerves, bones, ligaments, and other organs, in such a way as to alter their physical properties and positions, and thus to give rise to various physical signs. Now, all these physical signs are phenomena produced in the altered mechanism, in accordance with certain laws; and it is plain, that a comprehension of these laws must greatly assist to a ready understanding of the signs, and to a correct tracing of them to their true causes. Nay, even the aneurismal tumour itself, alike as regards its production, increase, and intrinsic signs, *can* be rightly understood only through the principles of hydraulics and dynamics, considered in connexion with the structure of the heart and arteries in health and disease.

606. *Vital symptoms* are those phenomena which depend on the *vital* properties of the textures and of the body as a whole. Thus irritability, tonicity, sensibility, excitomotion, secretion, and the

complex functions resulting from combinations of these elementary ones (§ 104), in a natural state, furnish the symptoms of health; and in a disordered state, constitute the symptoms of disease. Hence vital symptoms have also been called *functional*, and *physiological*; but both these terms are objectionable, because *function* and *physiology* have likewise to do with physical properties, and therefore concern physical signs.

Vital symptoms are often less confined in their expression than physical signs; because the vital properties of the entire system are in mutual connexion; thus the irritability of the heart spreads its influence throughout the vascular system; the sensibility of one organ or part affects the nervous centres, and often through them produces sympathetic symptoms in other organs or parts (§ 156); disordered secretion modifies the condition of several parts at once (§ 162—7, &c.); vital symptoms are, therefore, often generally distributed through the body. For this reason, they have been sometimes called *general* symptoms, to distinguish them from physical signs, which are chiefly local; but this appellation again is not precise, inasmuch as vital symptoms are sometimes entirely local; as is often instanced in the case of pain, spasm, &c.; and it has been already mentioned, that physical signs are sometimes themselves of general import, as illustrated in the yellowness of the whole surface in jaundice, the swelling of the body in dropsy, &c.

Vital symptoms are sometimes called *rational*, because their connexion with some particular cause is rather a matter of inference than of direct observation; but this is the most absurd designation of all; for observation is necessary as much to teach the value of symptoms as of physical signs; and physical signs are of little use unless they are duly made objects for the exercise of reason.

607. Vital symptoms are exemplified in pain, in uneasiness, and in altered and impaired sensations, which arise respectively from exalted, perverted, or defective sensibility (§ 125—136); in spasm and paralysis, which proceed from excessive or defective contractility (§ 110—118), or excitomotory power (§ 139—154); in cough, which is caused by irritation or undue excitability of the excitomotory nerves of the air-passages and muscles of expiration; in vomiting, which depends on irritation or undue excitability of the stomach and the excitomotory nerves sympathetically allied

with it; in dyspnœa, which arises from a feeling of want of breath (§ 234); and in fever, which comprises an accelerated pulse, hot skin, and diminished secretions, &c. (§ 437.)

Symptoms are further supplied by the state of the different bodily functions in which vital properties are concerned. Thus, the state of the pulse affords a great variety of symptoms: a frequent or a slow pulse indicates increased or deficient excitement or irritability of the heart (§ 113, 117); a strong or a weak pulse implies an increased or diminished strength of the heart's contractions (§ 112, 116). A hard or sharp pulse is in part dependent on an increased tonicity of the arteries (§ 121); whilst a soft, compressible, or liquid pulse, results from a diminution of this property (§ 123). Irregularity in the rhythm of the pulse arises from an alteration of the irritability of the heart, commonly connected with loss of strength. These various conditions of the pulse are sometimes consequences of diseases directly affecting the vital properties of the heart and arteries themselves; but more commonly they are induced sympathetically by diseases of other parts, or through the blood influencing these organs, as instanced in inflammatory fever (§ 437). Thus, in diseases of the heart and arteries, the quality of the pulse has more of the character of a physical sign; whilst in other disorders it is rather a vital symptom, connected with vital properties.

The state of the skin is another source of symptoms chiefly dependent upon the vital properties of the superficial vessels and secernent apparatus, and of the general circulation. Thus the heat and dryness of the skin in fever arise from accelerated circulation and diminished perspiration. When the skin is cold, the circulation is weak; when warm, it is active; but the occasional occurrence of perspiration in both these conditions proves that it is another vital property, namely that of secretion, that is concerned in determining dryness and moisture of the skin. The signs furnished by the skin are physical, in so far as regards the condition of that structure itself; but they are also vital symptoms in relation to the state of the circulation, and to that of distant organs, or of the system at large.

Many important symptoms are furnished by the appearances of the tongue. These, when arising from primary disease in the organ itself, are really physical signs of its condition. Thus, when the tongue is inflamed, it is first red and swollen, and after-

wards becomes covered with a film or fur, which, separating in patches, leaves the surface red, and smoother than before. But in a great many diseases, the tongue becomes red, swollen, furred, or brown and dry, in consequence of causes that act through the system: and these secondary affections of the organ then constitute symptoms of these general diseases. The connexion between febrile and other general diseases, and the appearances which they produce in the tongue, is not well understood; but the appearances probably depend on changes induced in the secretion of the mucous membrane and adjoining parts.

The alvine excretions supply symptoms of great importance in various diseases. When they are excessive in quantity, liquidity, and frequency, they constitute diarrhœa, which may be primary—that is, a disease in itself (§ 374); or secondary, and, therefore, a symptom of disease, as in cholera and mucous enteritis. Diarrhœa, as a symptom, presents further important indications accordingly as it is fæculent, bilious, mucous, or watery, for these diversities respectively point out that there is accumulation of fæces, or excessive secretion of bile, mucus, or watery fluid, in the intestines. The opposite condition, that of costiveness, is also sometimes a disease itself, and sometimes an important symptom of disease, indicating defective peristaltic power, or faulty secretion, or both, in the intestinal tube. The quality of the alvine evacuation as regards colour, shape, odour, &c., often supplies symptoms which lead to a knowledge of the nature of disorder in the alimentary canal or in the system. Thus clay-coloured fæces indicate defective secretion from the liver; those very dark in colour denote the presence either of diseased bile or of altered blood; vermicular shapes in the dejected mass may result from stricture or contraction of the intestinal tube.

The urinary excretion is a valuable source of symptoms, not only of diseases of the urinary apparatus, but also of disorders of other organs, and of the whole system. The kidneys being the chief emunctories through which foreign, effete, and superfluous soluble matters are eliminated from the blood (§ 254), the urine is continually exhibiting changes in quantity and quality, in colour and specific gravity, in the character of its sediments, and in the effects which different chemical reagents produce upon it. This all furnishes symptoms of several diseases; but these have been already noticed in detail in connexion with the several patho-

logical states involved (§ 167, 176, 249, 254, 255, 257, 260, 309, 384, 385, 448, &c.).

608. The foregoing illustrations of the sources whence symptoms are derived have been offered merely to point out where and how symptoms are to be sought for; to complete the list, it would be necessary to specify every function of every part of the body, and all the modifications to which they are subject; this alone would furnish matter to fill a large volume.

As a knowledge of the mechanism of organs, in health and in disease, and of the physical laws to which that mechanism is subjected, is the best aid to the study of physical signs, so an accurate acquaintance with the structure and functions of healthy and diseased textures, and with the vital laws which influence them, is the best guide to the comprehension of vital symptoms. These symptoms are often obscure and unintelligible, because physiology and pathology are imperfect; but in proportion as these sciences are improved, their application to the purposes of semeiology and diagnosis will become more satisfactory. In the mean time, much of what is known concerning symptoms rests mainly on mere experience; and until the results of experience can be more scientifically arranged it is convenient to consider them *numerically*, in order that some of the general laws which they express may be guessed out by empirical means. But to render this *statistical* or *numerical* method of studying symptoms at all safe, it is necessary that the numbers of observations shall be very large, that they shall all have been made in similar cases, and that the coincidences which are taken as establishing any rule shall greatly preponderate over the exceptions.

609. Physical signs and vital symptoms respectively possess their values in making known the nature and extent of disease. Physical signs are the more certain, because they appeal most directly from the seat of disease to the senses; they depend on simpler and more constant causes, physical properties, and are therefore themselves more constant, and less subject to variation than vital symptoms, which result from more complex, and therefore more variable, vital properties. Thus of the indications of inflammation, the redness, heat, and swelling are physical signs, and these more certainly prove the existence of this peculiar mischief than does pain, which is a symptom depending on the

property, sensibility, and which is often present where inflammation does not exist (§ 136), and which may fail to occur when inflammation is present (§ 433). The physical signs of a structural disease in the lungs or heart are surer evidence, both of its existence, and of its nature, than cough, dyspnœa, pain, or palpitation; because these symptoms may be produced by merely nervous or other causes, without the existence of any discoverable alteration of structure. Yet vital symptoms, although less sure and constant than physical signs, are often more delicate indications, in consequence of being present before physical changes become appreciable; and when they coexist with sensible signs, they at once express the nature and amount of disorder in the vital properties of the part, and of the whole system. Thus the feelings of chilliness and discomfort which usher in the fever accompanying tonsillitis, are sometimes experienced before the throat exhibits the physical signs of inflammation. A slight cough is often heard in the early stage of phthisis, before the physical signs of tubercles can be distinguished. Crepitation in the posterior regions of the chest is a physical sign of engorgement of the lung from effusion of liquid in the minute tubes; but we must refer to the accompanying vital symptoms to determine whether the engorgement is inflammatory or merely congestive. The physical signs of consolidation of the lung, and of valvular disease of the heart, are very obvious; but in order to decide whether these affections have arisen from present or recent inflammation, or are the results of old disease, it is necessary to consult the vital symptoms; and this decision is a matter of great importance in regard to both prognosis and treatment.

In short, both classes of indications ought to be carefully taken into account by the physician; and the more fully the physical and vital properties which constitute them are understood, the more available will signs and symptoms be in leading to correct conclusions, both in diagnosis and treatment.

610. Besides this distribution of symptoms into physical and vital, various other plans of classification have been proposed; but they are of little real utility, and it is, therefore, unnecessary to do more than succinctly enumerate them. Symptoms are *local*, or *general*, and *constitutional*, accordingly as they are confined to the diseased part, or as they affect the whole system. They are *idiopathic*, when directly proceeding from a primary disease; they

are *sympathetic,* or *secondary,* when arising from secondary disorders, or such as are produced by primary disease. *Premonitory* or *precursory* symptoms are such as precede the full development of a disorder, and commonly result from the first operation of the cause; hence they have been called *symptomata causæ. Commemorative* symptoms are such as are developed during the previous history of the disease. *Anamnæstic* symptoms, such as relate to the previous state of health. Signs have been divided into *objective,* those which present themselves to the scrutiny of the observer; and the *subjective,* those described by the patient himself. The objective have been further grouped as *active* or *dynamical,* those that require some action, motion, or manipulation, for their discovery; and *passive* or *statical,* those which are obvious without such agency. Symptoms are designated by the epithets, *diagnostic, prognostic,* and *therapeutic,* accordingly as they are specially applicable to the distinction, the foretelling of the event, or the suggestion of the treatment, of disease. Symptoms are *positive,* when they consist of phenomena actually present; *negative,* when they are expressed through absence of phenomena. Of diagnostic symptoms, those are called *pathognomonic* or *pathognostic,* which are peculiar to one disease. A single symptom or sign is rarely, if ever, pathognomonic; but two or three taken in combination often are so.

611. *Diagnosis* is the distinction of different diseases, one from another. It may be based upon their essential nature or pathology, or upon those groups of symptoms that are classed as separate diseases by nosological arrangements (§ 597). In other words, the object of diagnosis may be either to determine the intimate nature and seat of a disease, or to fix its place in some classification by a convenient artificial name. In the nosological arrangement, which has been alluded to as the best yet contrived (§ 600), the division of special diseases is, so far as is practicable, founded on pathology, or the essential nature of the disorder; and therefore diagnosis should also have a corresponding reference to this subject. But the admission has been freely made that pathology is not yet sufficiently advanced to admit of its being the sole basis of nosology; the physician therefore frequently has to avail himself of information derived from other sources in forming his diagnosis. A considerable portion of his materials, indeed,

are the results of simple observation or of clinical experience; and these, when they cannot be analysed by any more rational mode, may be advantageously estimated by *the numerical method*, which counts and classes the results of a large number of cases. Diagnosis is therefore chiefly based upon semeiology, and the results of clinical experience, arranged and interpreted by pathological and statistical science. In some instances, the causes and the treatment of disease aid the diagnosis. Thus the malarious character of a patient's residence, and the efficacy of quinine in effecting a cure, may contribute important evidence as to the character of a disease.

612. Diagnosis is *general* or *special*. *General* diagnosis comprehends the distinction between the elements or principles of disease (§ 104); as, for example, between congestion and inflammation; or between nervous irritation and structural derangement. *Special* diagnosis, on the other hand, relates to the distinction of diseases according to their chief seat, where they have one (§ 599); or otherwise according to some other specific difference. Thus, special diagnosis discriminates between inflammation of the parenchyma of an organ, and that of its investing membrane; or between an intermittent and a continued fever. Special diagnosis also distinguishes the further peculiarities of seat or character in disease; as, for instance, the part or extent of a parenchyma or membrane that is inflamed, the type of a fever, &c. Special diagnosis is therefore a branch of special pathology, and should be aided by an accurate and practical nosological arrangement. The distinction of two diseases, which resemble each other, has been absurdly called *differential diagnosis*. This is effected by marking the signs which are essential to the one, and not to the other. The signs called pathognomonic, are therefore the chief guides in differential diagnosis.

613. The best modes for investigating and distinguishing diseases vary very much in different cases, according to the nature of the symptoms that are the first to present themselves. This may be illustrated by the following problems:—

General pathology having pointed out the general nature of a disease, it is required to determine its precise seat. *Example.* In a case in which fever, hard pulse, buffed blood, and local pain indicate the presence of inflammation, the seat of the inflamma-

tion is determined by the chief seat of pain or uneasiness (in the chest or side), by the function most disturbed (difficult breathing and cough), to be in the organs of respiration; by the secretion proceeding from the part (rusty, viscid expectoration), and from the physical signs (impaired breath-sound and stroke-sound in part of the chest, with crepitant rhonchus), to be in the parenchyma of the lungs; that is, pneumonia. General pathology here commences the diagnosis, but it is completed by reference to symptoms explained by physiology and special pathology.

Previous history, prominent symptoms, or physical signs, having pointed out the seat of a disease, it is required to determine its nature. *Example.*—A person suffers from severe pain at the epigastrium; the previous occurrence of symptoms of indigestion and the situation of the pain, plainly show the disorder to be seated in the stomach: the nature of the disease (whether nervous or inflammatory, &c.) is to be determined by general pathology: guided by this, and finding an absence of symptoms of inflammation, no increased heat of surface, no acceleration of the pulse further than what the pain would cause, and no increase of the pain on the imbibition of warm or stimulating liquids; and finding symptoms of predominant nervous properties, and the sudden attack, intense character, and transient duration of the pain which distinguish nervous and spasmodic affections,—we decide that the disease is gastralgia or gastrodynia, and not gastritis. The diagnosis which is begun by local symptoms, is completed by reference to the principles of pathology.

Lastly, which is a common case, symptoms being too few or too inconclusive to lead the diagnosis, both the seat and the nature of the disease are to be determined. A person complains of general uneasiness, weakness, and chilliness, with various functional symptoms, but none of a prominent character. Clinical experience has taught the practitioner that such are the symptoms of incipient fever; and he proceeds to investigate further the nature and cause of the fever. If he finds, on close examination of the functions and physical condition of the different organs, that one is the seat of marked inflammation, and that the fever is not typhoid, he judges that the fever is symptomatic of the inflammation; but if signs of marked local inflammation be absent, yet the fever continues with increasing symptoms of depression, weak frequent

pulse, a brown dry tongue, sordes on the teeth, low delirium, &c., he recognises typhoid fever, resulting from the influence of a morbid poison on the system (§ 105).

614. Thus every department of medical knowledge is brought to bear on diagnosis; and in no branch is the information as well as the judgment of the practitioner more severely tested than by it. Natural shrewdness and tact, with some general knowledge of the nature and treatment of disease, may sometimes enable a comparatively ignorant person to practise medicine with an appearance of success; but such a person can never succeed with diagnosis; and he consequently either shrewdly evades the subject altogether, or expresses his opinions in conveniently vague terms, and scrupulously avoids their being brought to the test of the scalpel. The scientific and earnest inquirer, on the other hand, feels that this is the subject which demands, above all others, the strongest exertion of his mental powers and the keenest exercise of his faculties of observation; and that in proportion as his senses are well trained for the performance of their work, as his information is well arranged in relation to his observations, and as his judgment is matured in discriminating and deciding, will be his success in detecting the essential and intrinsic nature of disease, and in applying his knowledge to matters of prognosis and treatment.

615. In investigating the symptoms of a case with a view to diagnosis, prognosis, and treatment, the attention is naturally first drawn to such as at once declare themselves in the general *aspect* of the patient, the expression of the countenance, the complexion, the posture, the manner of the movements, and the speech; all these give important information to the observing practitioner at a glance, and whilst he is interrogating the patient. After the preliminary statements in the way of complaint, which are for the most part volunteered by the patient, the questions should be directed to the *history* of the ailment, including the *previous state of health and habits*, with regard to food, clothing, occupation, and residence, any former illness, *the mode of the present attack*, and its *supposed cause, preceding symptoms*, and treatment, if any has been employed. The answers to these questions will direct the inquiries, in the most efficient manner, towards the *present state* and *symptoms*; but the physician should be particularly careful never to permit himself to be so far led by the patient's statements as to omit to examine into the state of all the important organs

and their functions. The *nervous system and its functions,* (sensorial, sentient, excitomotory, and sympathetic): *the organs of circulation and their functions,* (pulsation of heart and arteries, capillary circulation of surface and visible parts, temperature, state of veins, &c.); *the organs of respiration and their functions* (breathing, cough, expectoration, voice, arterialization of the blood); *the organs of digestion and their functions* (tongue, appetite, and digestion); *the organs of secretion and excretion and their functions,* (liver and intestines, kidneys, bladder, and skin); *the functions of nutrition and assimilation,* (estimated by the condition of the flesh, and the comparative weight of the body); *the organs of locomotion and their functions,* (the vigour, firmness, and power of endurance of the muscles); *the organs of generation and their functions;* these are all subjects for inquiry and physical examination to such an extent as may be sufficient to point out how far each may be concerned in the production of the morbid results under observation.

The object of a complete investigation of the state of a patient should be not merely to determine the particular disease under which he may be labouring, but also to discover any peculiarities of health, as well as what is morbid, in his condition. The prognosis, or anticipation of the extent and event of the disease, and the judicious selection of treatment, require this full investigation. We have to consider, not merely *disease in the body,* but also *the body in disease,* and it is by losing sight of this great practical axiom, that minute or microscopic inquirers, who may be singularly successful in special diagnosis, often signally fail in prognosis and in practice.

CHAPTER VI.

PROGNOSIS—FOREKNOWLEDGE OF THE RESULTS OF DISEASE.

616. Prognosis is that knowledge which enables the observer to foresee the course, duration, and event of a disease. Like the treatment of disease, it may be either *empirical* or *rational.*

Empirical prognosis is founded on experience or observation only, and takes no regard of the nature of the disease or the reasons which determine the results. It consists in the recognition of *good* and *bad* symptoms—that is, of symptoms which have, in a great majority of cases, been followed respectively by a good or a bad result. This mode of prognosticating the events of disease was the only one that could be pursued in the early ages of medicine. The "prognostics" of Hippocrates chiefly depended upon the enumeration of good and bad signs; and the accuracy of the distinctions which he has drawn in this sense proves the extent and accuracy of his observation of the sources from which his information was derived. The same acute faculty of empirical prognosis is often acquired to a considerable extent by nurses or other non-medical attendants of the sick. These can often tell when a patient is getting better or worse, by the appearance of the countenance, by the state of the voice, by the condition of the mental faculties, of the strength, of the breathing, and of the excretions, although they may be in complete ignorance of the nature of the disease, and why the signs are good or bad. This kind of prognostic knowledge, although useful in enabling a person to pronounce what the existing state of a patient may be, falls far short of that which ought to be possessed by the scientific practitioner, who should not only have a greater number of prognostic symptoms within his reach, but should be able to foresee them, so as to anticipate, and, if possible, to influence them in a favourable manner.

617. *Rational prognosis* comprises the estimation of the impor-

tance and tendencies of a disease from a knowledge of its causes, of its intrinsic nature and symptoms, and of the power of treatment in regard to it. Like rational diagnosis (§ 614), it takes its evidence from all available sources, and makes the best possible use of this evidence by analysing it, and so determining its precise value. Thus, in the early stage of inflammation of the lung, the discovery of the nature and seat of the affection at once indicates the presence of a serious disease, whatever may be the state of the present symptoms. The practitioner in forming a rational prognosis, takes into account the extent of the inflammation, knowing, from experience as well as from reason, that this is a source of danger: he also ascertains the duration of the attack, and from the existing signs and symptoms judges whether the mischief is increasing or not. These considerations give him some insight into the severity of the disease, but his prognosis is then determined by further reflections. He knows that inflammation of the lungs, although always a dangerous disease, becomes much less so when it is at a stage and in a subject in which antiphlogistic remedies can be well borne: thus, at an early period, in a young and vigorous subject, even the most extensive inflammations may be cured by bloodletting and other means judiciously employed; but if the disease has advanced far, and the function of respiration has been for some days impaired by it; and if the subject be feeble, from infancy, from extreme age, from previous disease, from intemperate habits, from a complicating disorder, or from any other cause, the prognosis becomes more unfavourable, inasmuch as there is then little power in the system to bear the lowering influence of the appropriate remedies, or to withstand the effects of the disease itself.

To take another example. In continued fever, certain symptoms have been found by experience to be of an unfavourable character. The pathological practitioner profits by this experience, but he analyses the results and goes further. Knowing that the occurrence of petechiæ, congested face, and stupor, at the commencement of fever, are bad symptoms, he is also aware that they are so, mainly in proportion as they arise from the changed state of the blood induced by the depressing cause of the fever; and that when, as sometimes happens, they appear without a corresponding depression of the heart's power, manifested by extreme frequency and weakness of the pulse, they are by no means of

such unfavourable import, but may arise from mere plethora of the subject. Again; symptoms referable to the excitomotory system (§ 153),—such as subsultus, hiccup, and convulsive affections,—are generally unfavourable in continued fever; but they are so only when caused by the severe operation of the febrile poison on the nervous centres; they are of much less consequence when occurring in a nervous subject, in whom slight causes may induce them. The same remark may be made in regard to stupor, which is of most serious import when dependent on fever alone; but which may be induced by very slight agencies in hysterical subjects. The scientific pathologist is acquainted with these differences, and forms his prognosis accordingly. He can trace the danger of bad symptoms, beyond the symptoms themselves, to those interferences with vital functions which render those symptoms dangerous, and of which the symptoms are not always the true exponents.

618. As the limits of the work preclude the introduction of details, it must suffice here to enumerate the chief circumstances from which a rational prognosis is formed, and to illustrate them by examples. These may be arranged under the two general heads; 1. those relating to the patient or subject; and 2. those referring to the disease.

619. *The age of the subject.*—Acute diseases are ill borne at either extreme of age, for the powers of reaction are then less energetic and less able to sustain the struggle. Hence infants and aged persons are often carried off by acute attacks. Acute diseases prevail more in the young and in middle age, than in advanced life, in which affections tend to assume a chronic form; also from want of that power of reaction and resistance by which in more vigorous age morbid actions are thrown off.

The sex of the patient.—Nervous diseases are most common and obstinate in the female sex; but they are more serious as regards their results, in the male sex. The occurrence of the catamenia is often favourable, as their suppression is unfavourable, in the course of a disease. Pregnancy and lactation suspend or retard the progress of tuberculous, and other disorders of the nutrient function, but the cessation of these conditions often excites the suspended mischief into fresh activity. Eruptive fevers, especially small-pox and scarlatina, are peculiarly fatal to women during and shortly after pregnancy.

The temperament of the patient.—In the sanguine temperament disorders are apt to be acute, and to tend to a speedy termination, favourable or unfavourable; in the phlegmatic temperament, they are more inclined to be chronic, and the symptoms are latent or obscure; in the nervous temperament the symptoms become very prominent, and often cause much suffering and alarm when little or no real danger exists, and are likewise remarkable for their mutability.

Previous diseases of the patient.—The same disease having occurred before, either prevents or renders milder a subsequent attack, in the case of eruptive fevers, hooping-cough, &c.; but this increases the tendency to recurrence, and the danger, in case of apoplexy and most structural diseases. Albuminuria with dropsy is more curable, when ensuing after scarlatina, than when induced by other causes; but rheumatism following scarlatina and gonorrhœa, is often unusually severe and intractable. After continued fevers and other debilitating diseases, inflammations often assume a subacute or chronic form, in which they are liable to escape attention, and to produce serious organic disease.

Present diseases of the patient.—These generally increase the severity or intractability of any additional disorder, especially if they be structural. Thus infectious disorders and fevers are peculiarly fatal in persons who have diseased heart, lungs, kidneys, or brain. But moderate hypertrophy of the heart is rather a favourable circumstance in phthisis. Cutaneous, and some other external diseases, occasionally suspend attacks of gout, gravel, diarrhœa, &c. Extensive emphysema of the lung supersedes tubercles, and most other lesions of the parenchyma, but makes the bronchial surface and liver the seat of almost constant congestion or inflammation. Cancer arrests tuberculous disease, and reduces the proneness of the subject to inflammation.

Previous habits of the patient.—Habitual intemperance and excesses of all kinds enhance the danger of all serious attacks and accidents. Extreme privations and exhausting employments make persons liable to fevers and other depressing diseases, and reduce the powers that react against them; and so also do close confinement and want of sleep.

Condition of the patient at the time of the attack.—Extreme weakness, or exhaustion from whatever cause, renders persons *bad subjects* for most diseases. Plethora increases the intensity of

inflammatory affections. Simultaneous excitement of any organ, as for instance, of the brain by moral influences, is very apt to add a dangerous complication to continued fever.

620. *The cause of the disease.*—Epidemic, endemic, and infectious disorders, are mostly serious in proportion to the intensity of their cause. Thus the endemic of a hot climate is more dangerous than that of a cold climate: an infectious disorder propagated in close habitations is more severe, on account of the concentration of its exciting poison and of other co-operating influences, than one that arises from more diluted and simple infection. Some estimate may generally be formed of the probable severity of a disease, if the character of its source is known.

The situation and nature of the disease.—The more important to life the part attacked is, and the more the disease interferes with the function of that part, the greater is the danger. Thus the heart, the lungs, the medulla of the nervous system, the kidneys, and the blood, cannot be extensively attacked by disease without great risk to life; and if the disease goes on to affect structure, as in inflammation, the danger is enhanced in proportion. In a few cases disease attacking an unimportant part, as the skin or an extremity, may prove dangerous on account of its tendency to spread to other parts or to infect the whole frame, as in the instance of cancer, gangrene, inoculated poisons, and hydrophobia.

The extent and progress of the disease.—The greater the extent of the disease, generally the more serious it will be, if the case be one of inflammation; but sometimes the severity of the symptoms is not in proportion to the extent of the mischief: intense and circumscribed inflammation causes more marked symptoms than that which is extensive and diffused. The rate of the progress of disease materially influences its effect on life and health. Thus the structure of the lungs, heart, kidneys, or liver, may become diseased to a very extraordinary extent, without destroying life, if the advance of the lesion is gradual; whilst a third or fourth of the same amount of mischief would prove fatal, if induced suddenly.

621. *The character of the symptoms.*—Those symptoms augur favourably which show a power of moderate and regular reaction, and a return of the functions to their natural state. The removal or alleviation of the more distressing symptoms of disease—the

restoration of the natural appetites, and feelings, bodily and mental —the regaining of strength—returning regularity and moderation of the pulse and other signs of equalized circulation—the disposition to sleep tranquilly, and wake at the usual times—the renewal of interrupted or diminished secretions, often in increased quantity, as if after accumulation, as in the case of *critical* perspirations, deposits in the urine, &c. (§ 448),—are the chief signs of approaching recovery.

622. Bad or unfavourable symptoms are such as arise from impediment to one or more of the functions immediately concerned in the support of life, namely, the circulation of the blood, respiration, nutrition, or excretion. In proportion as these functions are speedily or extensively impaired, life is threatened, and there is an approach towards its arrest, by one or other of those terminations, which are called *modes of death.* Thus there is death by *syncope*—cessation of the circulation; by *asphyxia,* or *apnœa*—interruption of the respiration; and by *inanition.* To these may be added, death from the *pernicious influence of excrementitious matters,* and other poisons, which operate in various ways. These different modes of death are most distinctly exhibited when they are brought about so speedily as to leave the functions, which they do not directly affect, comparatively vigorous and as it were outliving that which has been more seriously injured. Thus, in sudden death from arrest of the respiration, the heart continues to act for some time, until the death which has begun with the breathing function reaches its intrinsic vitality also.

623. If we further trace the operation of these different modes of death, we shall find that they all agree in affecting the blood, either by altering its composition, or by arresting the circulation; and that it is through one of these means that death extends to all the functions of the frame. Thus in death from cessation of the heart's action, the circulation is at once arrested, and every part deprived of the material support of its vitality; hence this is the most speedy death that can happen. Inanition obviously operates by reducing the circulating material, and by ultimately weakening the organs by which the circulation is carried on. Asphyxia, we have already found (§ 235) both to impede the circulation and to alter the condition of the blood. Excrementitious matter retained in the blood, and extraneous poisons, admitted

into it, operate in various ways: sometimes by impairing the irritability of the heart; sometimes by injuring the medullary nervous function (§ 154), on which respiration depends; sometimes by arresting the passage of the blood through the capillaries, (§ 298); and sometimes (and this probably includes one or others of the former modes) by so changing the properties of the blood itself, as to render it unfit for its office of sustaining the activity of the several vital functions: the fatal operation of all poisons may thus be traced, like other causes of death, to derangement induced in the circulation or in the composition of the blood. It is the more necessary to keep these points in mind, because they explain why death from disease often takes place without beginning obviously in some one set of functions; all then fail together from want of proper blood, their natural support.

624. It may be as well to specify more particularly the principal varieties of the several modes of death, and to mention such symptoms, as may become available in prognosticating the approach of death.

Death (cessation of function) beginning at the heart { (
— — beginning at the breathing apparatus = Asphyxia or apnœa.
— — beginning at the brain = Coma.
— — beginning at the nervous medulla = Paralysis.
— — beginning in the blood = Necræmia (*νεκρος, dead; αιμα, blood.*)

625. Death by *cardiac syncope,* or sudden cessation of the heart's action, may occur in two ways—1. By this muscle losing its irritability (§ 116), so that it ceases to contract; and, 2. By its being affected with tonic spasm (§ 114), so that it remains rigidly contracted, and fails to enter upon its usual alternation of relaxation. In both these cases, death is quite instantaneous: the subject suddenly turns pale, and falls back or drops down, expiring with one gasp. In the first instance, both sides of the heart are, after death, found to be distended with blood; and if the examination be made soon after death, the blood in the left cavities is observed to be florid. In the second instance, the heart is small and very hard; the ventricles (especially the left) are so firmly contracted, that their cavities are almost obliterated, and contain no blood; the muscular substance is very firm; but in two or three days (particularly after maceration in water), the walls of the ventricles yield to the pressure of the fingers, and the cavities may

be restored to their normal dimensions. This state of the heart was long mistaken for concentric hypertrophy, until Cruveilhier and Dr. G. Budd pointed out its true nature.

Although syncope by loss of irritability (paralysis) and syncope by spasm, appear to be opposite states, yet they arise from somewhat similar causes. Wounds of the heart are followed sometimes by the one, sometimes by the other. Death by *shock*, instanced in the tearing off of a limb, the infliction of a violent blow on the epigastrium, and the crushing of the brain or spinal marrow, is sometimes caused by spasm, but more frequently by paralysis, of the heart. In sudden death induced by drinking a quantity of raw spirits, or of very cold water when the body is heated, the heart has been found contracted.

Syncope by loss of irritability of the heart is the more common occurrence; it may be caused by the operation of large doses of certain poisons of the sedative class—such as the upas antiar, infusion of tobacco, aconite, and digitalis; and in combination with other effects, by that of hydrocyanic acid, strychnia,* oxalic acid, arsenic, preparations of baryta, and various animal poisons. Mr. Blake proved experimentally that the power of the heart is destroyed by the injection of solutions of various saline matters into the veins, especially of salts of potass, magnesia, zinc, copper, lime, baryta, and lead; but these results do not correspond with what is ascertained to be the influence of the same substances when introduced into the stomach.

The diseases in which death by cardiac syncope sometimes takes place are—structural lesions of the heart (but more rarely than is commonly supposed); hæmorrhagic apoplexy, attended with much injury to the substance of the brain (§ 364); anæmia (§ 270); and adynamic fevers (§ 105). As this result occurs instantaneously, there can scarcely be said to be symptoms; but sometimes an approach to it is manifested in attacks of common syncope or faintness, in which the action of the heart becomes weak, irregular, and intermittent; and the partial failure of the circulation is evinced in the paleness of the face, lips, and general surface, together with cold perspiration; and there is suspension of the sensorial functions (*defectio animi*),—loss of consciousness and

* In my own experiments the heart was always found distended in animals poisoned by strychnia. In the late trial of Palmer, some of the medical witnesses stated that it is sometimes found contracted.

volition, more or less complete, sometimes attended with various convulsive movements (§ 153, 265)—the eyes turning up or becoming fixed or glazed, and the pupils dilated. The effects of altered posture on syncope have been already alluded to (§ 70); and they may be observed in cases which ultimately prove fatal. The recovery from this faintness is often attended with shivering, vomiting, sighing, gasping, yawning, and various distressing sensations of noises in the head, flashes in the eyes, palpitation, depression of spirits, &c.; the pulse, in the meantime, regaining its strength and regularity, and the colour and warmth returning to the surface. Subsequent reaction, like that which occurs after great losses of blood (§ 266, 362), is very apt to ensue.

626. Death by the *gradual cessation of the heart's action* has been termed *asthenia*, (*a, not, σθενος, strength*). This is the way in which many diseases terminate, especially those which destroy life by exhausting the strength, without exerting any direct interference with the more vital functions. Long-continued fevers, delirium tremens, gastritis, enteritis, peritonitis, and occasionally tetanus, hydrophobia, and inflammation of the brain; hæmorrhages, and various discharges of animal fluids—such as diarrhœa, diabetes, and the suppuration of extensive ulcers or abscesses, want of sufficient food, and several other like influences, thus reduce the power of the heart, and with it the vigour of the functions of the whole body, to a lower and lower state, until at length the heart flutters, and dies.

The symptoms of the approach of death by asthenia are—augmenting weakness of body and mind, probably without marked derangement of any particular function of either; increasing frequency, and diminishing strength of the pulse; the face, lips, and skin generally become gradually paler and paler, or of a death-like sallowness; the extremities lose their warmth, and often become œdematous; the appetite fails; the tongue is sometimes dry and brown, sometimes furred, and the mouth aphthous (§ 483); the excretions at first are imperfectly voided; then the sphincters lose their power (the weakness reaching the seat of the excitomotory function), and involuntary discharges of urine and fæces take place. This state of *sinking* terminates in death in a few hours. The symptoms thus described depend upon progressive loss of power, not confined to the heart, but through its failure, and that of the circulation of the blood, of which it is the chief instrument,

becoming extended throughout the whole frame. But with this general debility there are often indications of partial excitement and attempts at reaction, which sometimes mark the sinking state. Thus a febrile excitement of a hectic kind (§ 471) is very apt to come on, giving slight temporary strength to the pulse, a flush to the cheek, life to the eye, and a sort of flickering reanimation to the whole frame. Sometimes the excitement is more partial, affecting the brain, with a sort of delirium; or the medulla, and inducing *subsultus tendinum*, hiccup, and other slight convulsions; or the stomach, and causing vomiting, &c. Often, in the sinking state, some functions become obscured before others, in consequence of congestions, effusions, or even low inflammations occurring in the capillary vessels of their organs (§ 290), as the powers of the general circulation fail: thus, death by asthenia may become somewhat complicated with the coma of congestion or effusion within the head; or with dyspnœa from congestion in the lungs: or somewhat similar symptoms may arise from the early failure of the excreting organs, and the consequent retention of excrementitious matter in the blood (§ 249).

627. *Asphyxia* or *apnœa* has already been noticed as an element of disease (§ 234), and its nature and symptoms have been so far examined (§ 235); it must here be adverted to as a mode of death. By *death beginning at the breathing apparatus*, is intended to be expressed that in which the function of this apparatus is the *first* to fail. In this respect it is distinguished from death beginning at the brain or spinal medulla, which destroys by *secondarily* suspending the function of breathing, and the distinction is useful for practical purposes, since it serves to direct attention to the most suffering organ. Death by simple apnœa takes place in diseases of the lungs and air-tubes, in which the entrance of air to the lungs is impeded by effusion into these cavities; or by pressure upon them, as instanced in bronchitis, pneumonia, and pleurisy; or by obstruction to the passage of the air through the trachea or larynx, as occurs in croup, laryngitis, and tumours or spasm constricting the bronchi and cells; or by circumstances which mechanically prevent the entrance of air by the mouth and nostrils, as in smothering, strangling, hanging, and drowning.

The symptoms of the approach of this mode of death are—an increasing feeling of suffocation or want of breath, which becomes

most distressing and agonizing if the want be unappeased; the efforts at respiration are made in a hurried and forced manner; the face, neck, and other parts of the surface become congested in proportion to the violence of these efforts; and as they are unsuccessful, the colour of the congested parts changes from red to purple, and from purple to livid. The influence of the congestion and partial circulation of black blood (§ 235) soon tells upon the several vital functions, and becomes manifest in stupor, reduction of temperature, weak and irregular pulsation, rapid reduction of muscular strength, and consequently of the efforts to breathe. Hence the dark hue of the face is ultimately changed to paleness; but the lividity of the lips, tongue, nails, and other coloured parts, remains. In cases of speedy death from violence, as in hanging, or drowning, or from a sudden attack of laryngitis or spasm, the respiratory efforts are more vigorous, and the congestion and lividity of the surface are greater, and more persistent. But in the slower asphyxia of diseases of the lungs and air-tubes, the interruption to the breathing is less complete, the efforts are less violent, the congestion of the surface is less marked, and the functions fail more gradually and equally, and so the symptoms peculiar to apnœa are less decided. Here, too, as imperfectly arterialized blood is circulated throughout the body, this often causes peculiar symptoms, such as stupor and low delirium, partial paralysis, vomiting, relaxation of the sphincters, and other indications of sinking. This exemplifies what has been before remarked (§ 622), that the distinctness of the mode of death generally depends on the speedy supervention of the result.

As matters of prognosis, the symptoms of apnœa are more hopeless in proportion as they are conjoined with those of debility. The nature of the obstruction to the respiration must also of necessity be taken into account; if this be not complete, nor its cause irremovable, the congestion and lividity of the surface are not fatal signs, so long as the strength of the breathing apparatus and of the heart does not decline; but as this becomes exhausted, the means of recovery are lost.

628. Death by coma, or beginning at the brain, is caused by various influences which primarily destroy the functions of the superior masses of the nervous system. The chief of these circumstances are—obstruction to the circulation through the brain by pressure, (of effused blood, pus, lymph, or serum, of distended

vessels in apoplexy, of a depressed portion of bone in fractured skull, and from coagula within the vessels in anæmia) (§ 267); and the influence of various narcotic poisons, such as opium, alcohol in large quantities, carbonic acid, ether, or chloroform, introduced by inhalation (§ 128, 246), and sometimes the excrementitious matter of urine and of bile in the blood (§ 249).

The symptoms of *coma,* dependent upon the interrupted function of the brain, are insensibility and suspension of voluntary motion, the heart's action not being materially disturbed. These may come on in different modes. In apoplexy and after injuries of the head they generally supervene suddenly, and the patient at once becomes powerless and senseless, the pulse continuing pretty good, although slower and fuller than usual, or it may be frequent from mere sympathy. In other cases, the stupor advances gradually, the senses and mental powers are irregularly obscured, and there are dimness of sight, appearances of clouds or cobwebs before the eyes, *muscæ volitantes;* various imperfections of hearing, odd noises, or *tinnitus aurium;* numbness and tingling sensations in the limbs; loss of memory, confusion of ideas, hallucinations, low delirium alternated with stupor (*typhomania*); continued somnolency, &c. Partial paralysis often accompanies progressively advancing coma, sometimes it seizes on the lower extremities (*paraplegia*), more commonly upon one side of the body (*hemiplegia*). In the operation of narcotics, the state of coma is commonly preceded by cerebral excitement, manifest in the usual signs of intoxication and delirium, but varied in the case of different poisons. For these particulars, however, works on toxicology and materia medica are to be consulted.

In conjunction with these symptoms, referable to disturbance of the sensorial and voluntary functions, there are often various affections of the excitomotory system of the spinal medulla; at first these are of the nature of excitement, such as convulsion, vomiting, hiccup, contracted pupil, &c. (§ 152). Thus, the coma of apoplexy, and the stupor of narcotism, are occasionally accompanied by convulsions (§ 150), general or local. I have elsewhere (§ 153) endeavoured to explain how these opposite effects may arise from the influence of the same cause on different parts of the nervous centres. But in cases of extreme coma, the excitomotory power that leads to involuntary motions becomes impaired, the breathing is stertorous and imperfect, the actions of coughing and

expectoration are not easily effected, deglutition becomes impossible, the pupils are dilated, emetics fail to excite vomiting, the sphincters are relaxed, and involuntary discharges of urine and fæces take place. The last group of symptoms have been already noticed as of fatal import in coma and narcotism (§ 154).

It is a question whether the functions of the brain can be completely suspended for any length of time without those of the spinal medulla suffering also. During common sleep there is not complete insensibility or suspension of volition, for movements are made in it under the influence of unpleasant sensations, without the sleep being broken. It is probable that in the trance of nervous subjects—of hysterical coma—(§ 141), neither sensation nor volition is entirely abolished; but it is difficult to ascertain the truth in these cases, for the patients often deceive themselves as well as others. But in the heavy sleep of intoxication, and in the stupor of coma, where pinching scarcely excites any evidence of consciousness, the functions of the spinal medulla seem to be impaired, as well as those of the sensorium, for the breathing is slow and stertorous, and irritations of the nose and eyes less readily than usual excite the motions of sneezing and winking. It is in proportion as these functions are impaired that coma becomes dangerous; and it is because they are not impaired (but in some instances distinctly exalted, as manifested by the sighing and spasmodic twitching that occur) in nervous or hysterical stupor, that this is unattended with danger. It appears probable, however, that coma, when complete, may cause death by the abolition of sensation only, and if so, we are warranted in distinguishing between death by coma and death by paralysis of the spinal medulla. Although the movements of breathing are ordinarily independent of the consciousness or will, yet such is not the case with regard to the extraordinary movements which are performed in breathing deeply or sighing, when the usual action is impeded by a confined position, fatigue, exhaustion, or some special debilitating cause. Under these circumstances, when the function of the brain is unimpaired, the feeling of want of breath arouses a succession of voluntary efforts, which issue in suspirious breathing, and which are the cause of the sleeplessness of delirium tremens, and other states of exhaustion (§ 154). But when sensibility and voluntary power are wholly suspended, these supplementary efforts are not made; for want of them, the respiration is

then insufficiently performed, and the lungs and air-tubes gradually become congested; this congestion and the secretion consequent upon it further impair the involuntary part of the process, and thus without any indications of paralysis of the spinal medulla, the symptoms and effects of apnœa are slowly superinduced on the state of coma. Under such circumstances, it is of great importance to place the patient in postures and circumstances that are most favourable to the movements of breathing, and to attempt to remove pulmonary congestion by appropriate remedies, should it arise.

Snoring arises from a relaxed state of the soft palate, and is of little moment so long as the movements of breathing are duly strong and frequent; but when the respiratory powers are weakened, stertor is not only a sign, but a cause also of obstruction to the passage of the air, and should be prevented as much as possible by changing the posture of the patient.

The most dangerous kinds of coma, then, are such as are attended by symptoms of impaired excitomotory function, or such as are so profound and prolonged, as to deprive the respiration of all aid from voluntary efforts; the signs of danger are therefore particularly connected with the state of breathing. In apoplexy, contraction of the pupil of one or both eyes is of very unfavourable import, because it indicates that there is irritation of the upper portion of the spinal medulla, as well as oppression of the brain: such a combination can only proceed from the influence of a blood-clot upon the substance of the nervous centres, compressing one part and irritating another.

629. It is quite intelligible why death ensues from *injured function of the medulla oblongata and spinalis*, when it is considered that the ordinary act of breathing depends upon this portion of the nervous centres. This mode of death, like the last, is of the nature of apnœa; but the failure here begins with the nervous link of the chain of actions which constitute the process of respiration; whereas in simple apnœa, it commences in the mechanism of the breathing apparatus.

This form may be called death by *paralysis*, and as in other cases of paralysis of the excitomotory function (§ 144), the result may be caused by suspended function, either of the nervous centre, (medulla oblongata), of the afferent nerves (parvagum and sympa-

thetic), or of the efferent nerves (phrenic, intercostals, and spinal accessory), which complete the respiratory circle. Amongst influences which destroy the function of the medulla oblongata itself, may be mentioned, hæmorrhagic effusion into or upon the medullary substance, fractures of the base of the skull, and any very considerable pressure on the whole encephalon. I have witnessed several deaths from encephalic hæmorrhage, in which the stroke was not attended with complete loss of consciousness, and could not therefore be termed apoplectic; it was simply paralytic, with loss of power of articulation, with hemiplegia, and with laborious and stertorous breathing: this latter condition exciting voluntary efforts or struggles, the patient by gesticulations, and violent gaspings, showing his consciousness of the failing respiration. In two such cases, in addition to some hæmorrhage into one hemisphere of the brain, there was a clot in the pons Varolii. Instances of this kind establish the truth of the distinction between the death by coma and death by paralysis. Some poisons affect the spinal medulla more immediately than the brain. Thus, animals poisoned with woorara, essential oil of bitter almonds, conia, belladonna, and perhaps other agents, are affected with gaspings and other signs of impaired function of respiration before they lose consciousness; according to the experiments of Sir B. Brodie and others, they die simply from the suspension of respiration, and if this process be artificially maintained for a time, they may possibly recover from the effects of the poison. The same remark applies in a degree to opium and its active principle, but less forcibly, for these induce coma early, and often impair the action of the heart also. Experiments are wanting to establish the elementary operation of this and other poisons, and to connect the same with the views physiologists now hold regarding the several functions. In some cases in which animals have died under my observation, from rapid hæmorrhage, the respiration has ceased for some seconds before the heart's action; and from the peculiarly laboured state of the breathing, and late retention of consciousness, I have been induced to conclude that death from hæmorrhage, in some instances at least, is due to suspension of the functions of the spinal medulla.

630. The division of the eighth pair of nerves in the neck of animals illustrates one mode by which paralysis induces death. These are the chief incident or afferent nerves that run from the

lungs to the spinal medulla, and that transmit the impressions whereby the motory nerves of the muscles of respiration are excited. When they are divided, the breathing is imperfectly performed, and expectoration and cough cannot take place; apnœa, therefore, gradually follows. Although disease does not exhibit precisely the same result, yet an approach to it is seen in the dyspnœa, sometimes constant, sometimes in paroxysms, which the pressure of tumours on these nerves, or malignant disorder involving their structure, causes.

631. The third mode in which the nervous link of respiration may be broken through injury of the excitomotory column of the spinal marrow or its branches, is exemplified when the neck is broken, or the upper cervical vertebræ are dislocated. Pithing an animal acts in the same way. All parts supplied by nerves from below the injured portion of the medulla become paralysed, and therefore their motions cease. Diseases in the vertebræ, in the spinal cord, or in its membranes, have been followed by similar results; and the functions of the several nerves of respiration are illustrated by these cases. I have known disorder affecting the cord at the upper cervical vertebræ to cause loss of motion in all parts below the neck except the diaphragm, which is supplied by the phrenic nerve; the respiration was for a while entirely carried on through it. The patient afterwards regained power in the spinal accessory nerve, and was able to elevate the upper part of the chest; and subsequently the superior intercostal nerves and muscles resumed their functions for a time.* In other cases, disease of the spinal cord creeps from below upwards; there is then first paralysis of the lower extremities and pelvis, next of the intercostal muscles, and at last of the neck. The advance or retrogression of these symptoms is of great importance in the prognosis of such diseases.

632. The functions connected with excretion are also dependent on the integrity of the spinal cord; they fail when it is seriously injured, and the failure may furnish indications of death, beginning at this organ. When the cord is affected only at a point, and remains healthy above and below it, the mischief may merely intercept the transmission of sensation upwards, or of volition downwards, beyond the injured part. Hence, there may be loss of sensation, or of voluntary motion, or of both, in the lower por-

* Med. Chir. Trans. 1843.

tions of the body. If the paralysis reach the urinary apparatus, the power of spontaneously voiding urine is lost. But the reflex or independent excitomotory influence of the spinal cord remains, the sphincters and the bladder retain their power, and when the catheter is introduced into the latter, it contracts as usual, aided by the voluntary action of the diaphragm and abdominal muscles. It has been before noticed (§ 149), that under these circumstances the muscles of the lower extremities retain and accumulate their irritability, and although the will has no command over them, tickling, or even touching them, excites them to contract with unwonted energy (§ 141). The exercise thus incidentally induced seems to be sufficient to preserve their nutrition, for they do not waste away.

But the matter is altogether different when the spinal cord is extensively injured, by crushing, softening, or by a considerable effusion of blood or pus into its sheath. Its function then ceases, not only as a communicator of sensation and voluntary power to the lower parts of the body, but also as an originator of that involuntary excitomotory power by which the sphincters contract and the urinary bladder evacuates its contents. Hence, there is constant dribbling of urine, yet without the power completely to empty the bladder. The fæces are discharged unconsciously, and without control. The limbs are not only insensible and inobedient to the will, but their muscles can no longer be excited by tickling: they lose all capacity for motion, and the blood-vessels are devoid of the influences which nerves of all orders exercise upon them. It is not surprising, under such circumstances, that the death which has begun in the spinal cord should spread to the parts whose functions that organ can no longer maintain. The urine, imperfectly discharged, putrifies, and causes inflammation of the bladder, which may gradually extend to, and stop the secreting operations of, the kidneys. The intestines become distended and obstructed with gas and pent-up fæces. The proper circulation of the limbs fails for want of due movement and nervous influence in and upon the muscles and vessels; their nutrition ceases, they become œdematous, partially inflamed, livid, and at length gangrenous: all these changes are so many signs of the progress of death which has begun in the spinal cord.

From the remarkable effect of cold and particular poisons on some of the lower animals, inducing, as they do, paralysis of the

hinder extremities, it is probable that these agents operate injuriously principally by affecting the function of the spinal cord, beginning with the part most remote from the sensorium. Is the gangrene of the lower extremities, sometimes induced by the use of ergotted corn, in any way connected with injured function of the spinal cord?

Death of the spinal medulla supervenes on that beginning with coma and asthenia in many cases; and as the involuntary excito-motory function of this organ is the maintainer of many processes essential to life, the symptoms dependent upon its derangements are of great importance in connexion with prognosis. (See § 154.)

633. *Necræmia*, or *death beginning with the blood*, is a term which I venture to give to those fatal cases where the chief and most remarkable change is exhibited by the blood. In typhoid fevers, and other analogous malignant or pestilential disorders (§ 105), none of the solids of the body exhibit invariably such an early change of function or of structure as warrants the tracing of death to them. It is true, that the offices of many solid textures are impaired—the muscular and nervous systems, secretion, digestion, assimilation, and nutrition, all suffer; but the very universality of the affection seems itself to point to some more general cause, as the ultimate seat of the mischief, than can be found in any individual function; and such a cause may be found in the blood. This liquid, at an early period of these diseases, when they occur in their worst form, exhibits changes which show that disorder begins in it, and this disorder may reach to a fatal degree. The appearance of petechiæ and vibices on the external surface, the occurrence of more extensive hæmorrhages in internal parts, the general fluidity of the blood (§ 196), and frequently its unusually dark or otherwise altered aspect (§ 186), its poisonous properties as exhibited in its deleterious operation on other animals (§ 259), and its proneness to pass into decomposition, point out that the circulating fluid is the essential seat of disorder; and the failure of its natural properties as the vivifier of all organs and functions (§ 182, 263), is plainly the mode by which death begins in the body. How far the change is in the structure (§ 189) and vital properties (§ 211), or in the chemical composition of the blood (§ 181), further research alone can determine; the vivifying power of the blood depends on all these together,

and it is manifestly this which fails. Hence the complete adynamia, or general prostration of vitality which occurs where this cause of death is most energetically operative. The blood, the natural source of life to the whole body, is itself dead, and spreads death through the frame instead of life. Almost simultaneously, the heart loses its power, the pulse becoming very weak, frequent, and unsteady; the vessels are deprived of their tone, especially the capillaries of the most vascular organs, and congestions occur to a great extent (§ 290, 293): the brain becomes inactive, and stupor ensues; the spinal medulla is torpid, and the powers of respiration and excretion are imperfect; voluntary motion is almost suspended; the secretions fail; molecular nutrition ceases; and at a rate much more speedy than in other modes, *molecular* death follows on *somatic* death—structures die and begin to run into decomposition as soon as the pulse and breath are suspended; nay, a partial change of this kind occasionally even precedes the death of the whole body (somatic death—Dr. Pritchard*), the fœtid aphthous patches in the throat, and the offensive colliquative diarrhœa of persons in the last stage of various fatal diseases; parts running into gangrene, as instanced in the carbuncle of plague, the sphacelous throat of malignant scarlatina, and the sloughy sores of the worst forms of typhus, and in the large intestines in dysentery, the putrid odour exhaled even before death† by the bodies of those who are the victims of certain pestilential diseases,—these are all so many proofs of the premature triumph of dead over vital chemistry.

634. The above illustration is an extreme case; but there are many other instances of a slighter kind in which disease begins

* See Dr. Symond's interesting essay on "Death," in the Cyclopædia of Anatomy and Physiology.

† Certain anecdotes usually considered to be superstitious, derive some degree of probability from the above considerations. It is said that some of the lower animals, especially dogs and rats, have an instinctive foreknowledge of the approach of death in a house. I have known two instances, in which for two days before a death and subsequently until the body was removed from the house, rats from the drains infested the basement of the house to a degree never approached before or since. It is possible that a deathy odour (of which some sensitive persons profess themselves to be conscious) may be perceptible to the acute olfactory organs of these animals; or perhaps a more substantial cause of attraction may be presented in the putrid excrementitious discharges commonly thrown down the drains under these circumstances; some countenance is afforded upon the same principle to the still more marvellous assertions generally made by sailors, that sharks pertinaciously follow a ship that bears a dying man or corpse.

with the blood, and in which various disturbances and reactions result. The agents which appear thus primarily to affect the blood in an injurious way, are especially the endemic, epidemic, and infectious influences (§ 81, 88, 93), animal and vegetable poisons, like that of the most venomous reptiles and certain fungi, and probably some minerals, such as sulphuretted hydrogen, selenium, and, in part of its operation, arsenic. The direct influence of all these agents is depressing (§ 105), and when they act in large quantities, or in a concentrated form, the vital powers fall quickly into a state of adynamia or prostration, which soon issues in death, after the manner which has been already described, the blood having first invariably manifested a change. But if the noxious influence is in smaller quantity, or in a more diluted condition, the vital powers react against it (§ 16) in various ways, the object of the reaction mostly being its expulsion from the system. The shivering, hot stage, and sweating termination, of paroxysms of intermittent fever; the analogous, although less marked series of febrile derangements which occur in slight forms of remittent and continued fevers; the profuse and violent fluxes from the stomach and intestines in cholera, dysentery, and epidemic diarrhœa, and the somewhat similar discharges induced by poisonous ingesta, are all instances of vital reaction attempting the expulsion of noxious matter and of some part of the animal fluids corrupted thereby. But these struggles frequently constitute serious diseases, in which life may be compromised as much by the violence and exhausting effect of the reaction, as by the prostrating influence of the cause of the disease: in these more complex affections, individual organs suffer especially in different cases, and the danger and cause of death may exist less in the changed condition of the blood than in the results thus induced, or the exhaustion secondarily consequent upon them, so that death ultimately takes place, not by necræmia, but by coma, asphyxia, or asthenia, modes of death already considered.

635. The injurious effect of these poisons may be still more completely prevented when their quantity is small and the living powers are vigorous. A diarrhœa, a profuse sweat, or a free flow of urine, sometimes carries off the commencing disease. The intestines, the skin, and the kidneys, appear to be the proper emunctories through which morbid matter is expelled. The peculiar fœtor of the secretions from the bowels in typhoid fever; the

beneficial influence of moderate diarrhœa, in the early stage of fever; and the appearance of a foul fibrinous substance (typhus-material, of German writers,) in the intestinal glands in typhus, all seem to be examples of the elimination of a morbific matter. It has been already suggested (§ 404, note,) that the frequent follicular inflammation, ulceration, and sloughing of the intestines in fever, may arise from the excessive irritation of the secreting follicles during the exercise of this their eliminating function. Again, it has been mentioned, that granular degeneration of the kidneys, which impairs the eliminating power of these organs, renders the body peculiarly liable to contract epidemic and infectious diseases, and to succumb under them (§ 260).* On this account the prognosis of these cases is unusually unfavourable. These remarks apply equally to persons who have been habitually intemperate. On the other hand, those whose kidneys are naturally very active, resist disease more effectually, and throw off its effects more readily (§ 448). In like manner, it is well known that patients with an habitually dry skin do not get rid of a fever so easily as those in whom perspiration is readily excited.

636. Besides these influences introduced from without (§ 634), which attack the blood first, and in extreme cases injure its composition and cause its death, there are others of like nature, but which originate in the body itself. Thus the processes of gangrene and suppuration occasionally infect the blood with a septic poison (§ 470, 475), and cause death much in the same way as the disorders alluded to. The sudden suppression of the excretions of urine or bile, by disease, or by the influence of any severe shock, also seems in some cases to operate by injuring the properties of the blood; whilst in other instances it distinctly induces coma or asthenia. The retention of excrementitious matter has been elsewhere adverted to as a cause of *cachæmia*, or depraved state of the blood (§ 249, 564); it is the same occurrence in an extreme degree, that sometimes causes *necræmia*, or death of the blood.

637. The symptoms which should awake suspicion of the approach of death by necræmia may be gathered from the preced-

* This was well exemplified in the case of an epidemic erysipelatous angina, which attacked several patients of the University College Hospital in the spring of 1843. About a dozen persons suffering from other diseases, were affected; of these three died from *the erysipelas extending to the larynx, and in all these the kidneys were granular and* the urine albuminous.

ing descriptions. They are generally called typhoid, putrid, or malignant. For example: a congested appearance of the whole surface, the colour being dusky or livid, and extending to the conjunctivæ, tongue, and fauces: various slight exanthematous or papular patches on the skin, often with petechiæ; more extensive hæmorrhages in form of ecchymoses, or oozing of thin bloody fluid from the gums, nostrils, and sometimes from other passages; extreme prostration of strength, with an obtuse state of all the senses and mental faculties, occasionally combined with delirium and twitchings of the limbs; half-closed eyes and dilated pupils; a very quick, weak, and soft pulse; frequent and unequal respiration; absence of appetite; intense thirst; a dry, brown tongue, with dark sordes on the lips and teeth; a progressive fall of temperature, from the first febrile elevation; cold, clammy, and fœtid perspiration; hiccup; subsultus tendinum; scanty, offensive urine; involuntary discharges.

Some diseases of the same class are modified by peculiar circumstances. Thus in malignant cholera, excessive discharges of serum, by vomiting and by stool, render the blood so thick that it can no longer circulate through the vessels; the pulse then ceases, and the surface becomes blue and cold from the darkness and stagnation of the blood, and shrunk from the exhaustion of its fluid. In yellow fever, altered blood is ejected from the stomach in the form of what is called black vomit. But this subject belongs properly to special rather than to general pathology.

638. It has been stated, that the perfect distinction of these different modes of death is almost exclusively confined to cases where the dissolution is speedy or sudden. In the slower process by which diseases generally prove fatal, all functions and structures are more or less involved; and the life in all is then dwindled down to so slight a thread, that when it breaks in one, it is so immediately afterwards lost to the rest, that it is exceedingly difficult to determine where the disruption has first taken place.

CHAPTER VII.

PROPHYLAXIS AND HYGIENICS.

639. *Prophylaxis* treats of the means by which particular diseases can be guarded against; *hygienics* relate to the prevention of diseases in general, or, in other words, to the preservation of health. The former is connected with special rather than with general pathology; and is rationally founded on a due knowledge of the causes, nature, and tendencies of disorders, and of the various circumstances in regard to diet, regimen, residence, and medicine, which are capable of removing the causes, or of counteracting their operation.

640. *Hygienics** consist of the knowledge and application of the means, by which the structures and functions of the body may be kept in that normal state which conduces to their continued welfare—that is, in *health* (§ 6). It has been seen, that both structures and functions have the elements of disease in themselves, when anything disturbs their due relations. The circumstances which lead to such disturbance, have been noticed both in connexion with the causes of disease (under the head *Etiology*), and in connexion with its intimate nature (in the division *Pathology proper*); and remarks on the medicinal and other influences whereby such circumstances may be prevented or counteracted were introduced in the context to a sufficient extent to have served to suggest the principles of hygienics. It will therefore be sufficient in this place to consider briefly the principal matters which are concerned in the maintenance of health, and these may be arranged under the following heads:—*Food; Clothing; Temperature; Air; Exercise; Mental Occupation; Sleep,* and *Excretion.* The nature of the work precludes the possibility of dwelling

* I use this term (derived from the Greek ὑγιεινικος, relating to health, and analogous to *optics, acoustics,* &c.) as more conformable to our language than the French term hygiène.

upon the details of these important topics; and the following is intended as a mere outline in conformity with the principles previously explained.

FOOD.

641. The object of food being the supply of materials, which after preparation by the process of digestion, shall repair the waste of the body and maintain its temperature, it is obvious that the purpose will be best effected when the supply is of such quality and quantity, and so administered, as to suit respectively the powers of digestion and the wants of the system for nourishment and warmth; in other words, food should be digestible, nutritious, and califacient, and the articles which duly comprise all these qualities will be the most wholesome food.

642. The importance of a due combination of the chief alimentary principles, albumen, oil, and sugar or starch, with water as their diluent, in substances employed as food, has been pointed out (§ 58); and the expediency of selecting such materials as comprise these in the best quality or condition, may also be inferred from preceding observations (§ 60). But it will hardly be superfluous if the subject is further illustrated by a few comments on common articles of diet.

Wheaten bread comprehends the albuminous (gluten) and the amylaceous principles, and it only needs the addition of butter to complete the requisite combination for moderate nutrition. The goodness of bread depends not only on the character of the grain from which the flour is obtained, but also on the mode and degree of its fermentation and baking. If fermented with leaven instead of yeast, or if over-fermented, acetic acid is generated, and the bread becomes sour; this is the common fault of bread in large towns where the supply of yeast is insufficient, and it prevails generally on the continent. The evil is avoided in the unfermented bread, which is rendered porous by an effervescence of carbonic acid gas, caused by an admixture of carbonate of soda with the flour, and hydrochloric acid with the water, with which the dough is made; when well prepared such bread is very sweet and free from acidity, but unless carefully manufactured it is liable to be heavy, and, like imperfectly fermented bread, it is then unfit for mastication. Bread insufficiently baked is glutinous and indigestible,

and so also is quite new bread which has not dispersed its moisture. These defects may in great measure be remedied by toasting it in thin slices; this expedient has also the advantage of dispersing much of the acid from sour bread. Very white bread is objectionable as being less nutritious (having less gluten) and more constipating than that made with less refined flour: but the coarse material commonly sold as brown bread errs to the opposite extreme, from containing a bran that is coarse enough to be irritating to many stomachs. Good country bread fermented with yeast, and well baked, is the kind most generally wholesome.

Meat comprises in itself the albuminous, oily, and gelatinous principles, besides creatine and other soluble extractive matters, also probably nutritious. It needs to be combined with vegetables or bread to make it agreeable to the palate and stomach. The object in keeping and cooking meat is to render it so tender that it may be easily softened by the gastric juice, and all processes which interfere with or go beyond this result, render it less wholesome. Thus salting, pickling, hanging until it becomes tainted, and hardening by over-cooking or fast boiling, which corrugates and toughens the fibre, are so many ways of spoiling meat for the purposes of digestion, and rendering much of its nutriment unavailable. The flesh of young adult animals presents the greatest amount of fibrinous material; that of younger animals contains more gelatine and fat; and that of very old ones is tough from the prevalence of more condensed fibrous textures, which however are converted into gelatine by boiling, and are therefore useful for the formation of soups. Different kinds of animal food vary much in their composition, even when the lean parts only are selected. Thus beef and pork contain a large proportion of fat; mutton has somewhat less; and in the flesh of fowl, game, and white fish, there is only a very small amount. This affords an explanation of the fact that the latter articles make the best food for persons of weak stomach. But the proportion of creatine and coloured extractive matter doubtless also has to do with the quality of the food; thus the flesh of hare, which contains much of these constituents, is more heating than that of chicken and whiting or sole, which may be taken to be the types of the mildest form of solid animal nourishmeut. The lean of veal contains very little fat, and is therefore not objectionable on account of its richness; but it often disagrees, probably in consequence of the calves

being so much drained of blood before they are killed, that the muscular acids predominate. Veal well stewed with rice is less unwholesome than in other modes of cooking. Soups and broths, when deprived of excess of fat, are very useful articles of nourishment used as auxiliaries to solid food, but they are not substantial enough to supply a meal to a healthy person. Eggs and milk, separately or combined, form light and nutritious articles of diet. They are rendered easier of digestion by being heated to about 180°, by which part of the albumen is slightly coagulated. Both eggs and milk contain a considerable amount of oil, which causes them, when taken too freely, to disagree with persons of bilious habit. They are also prone to speedy decay, and lose much of their wholesomeness, even in a day or two. Fresh butter is an excellent adjunct to bread and vegetable substances; but it likewise soon becomes rancid and loses its salubrious properties. Cheese is a low form of a protein compound, and requires energetic digestive and assimilating powers to raise it to the higher standard of the material of the blood-plasma, and being unassimilated, it tends to increase the lithic acid in the blood, and to promote gouty and kindred disorders; it is therefore wholly unfit to be used as food by delicate persons, and those of weak digestion.

Oleraceous and succulent vegetables and fruit are fit adjuncts to the more nutritious articles of food, which they serve to dilute, and by the subacid and extractive matter which they contain, they promote the secretions, and thus tend to purify and cool the blood. But, excepting in the case of perfectly ripe fruit and salad, they require to be thoroughly cooked, in order to give them the state of softness favourable to the digestive process.

643. The selection of the articles employed as food, and the arrangement of the hours for the different meals, must vary considerably with the habits and occupations, as well as with the strength and tastes of individuals; but the following plan of diet, with occasional slight modifications, will be found suitable for most healthy adults.

Breakfast at from eight to nine, A.M., of bread or dry toast with a moderate quantity of butter. One or two new laid eggs, boiled three minutes and a half; or a little cold chicken or game, or even a mutton chop, may be added for those who use much bodily exertion. Beverage, one breakfast-cupful of *café au lait*; that is, clear strong infusion of coffee with scalded milk, in the

proportion of one-third of the former to two-thirds of the latter. Cocoa deprived of its oil, or thin chocolate with milk may be substituted for the coffee, if preferred.

Luncheon, at from one to two, P.M., may consist of a small basin of good shin of beef soup, with vermicelli, rice, or toasted bread in it. If meat have been taken at breakfast, a biscuit or piece of bread and butter, or small sandwich may suffice for luncheon; wine and malt liquors are generally better avoided at this time.

Dinner at from five to seven, P.M. (The latter hour is not recommended, but is often unavoidable.) Wholesome fresh meat and vegetables, well but plainly cooked, served hot, carefully proportioned, and properly masticated; these should be varied from day to day, with occasional additions of fish, and moderate quantities of farinaceous or fruit puddings. Highly seasoned dishes, pickles, salt and dried meats, rich and heavy pastry, and cheese, should be excluded from tables aiming at wholesomeness. Beverages:—sound white wine, (sherry or good Marsala, from one to three glasses,) which it is advisable to mix with water; or good Sauterne or Moselle unmixed. Those who use much exercise may safely substitute malt liquor, bitter ale being the lightest, and porter or stout the more sustaining. Half a pint is generally as much as is well for the health. Many thrive, especially in the country, without any fermented liquor. If simple water be taken, it should be in moderation, otherwise it may interrupt digestion. Some find warm water, or milk and water, a pleasant beverage. The habit of taking wine after dinner is one of luxury, not of health, and all that can be said of it in a hygienic sense, is—the less the better. The practice of making a slight dessert of fruit is not equally hurtful, provided its quality or quantity be not such as to excite indigestion.

Tea. The English custom of taking tea, or a simple warm liquid meal three or four hours after dinner is a very salutary one, and probably disagrees only with those who dine too late or overload the stomach at dinner. The warm liquid assists the separation and absorption of the chyle from the chyme which is effected at this period. But it is obvious that the introduction of solid food into the stomach with it must interfere with this process; therefore little or nothing should be eaten—certainly not quantities of buttered toast and rich cake. Two or three moderate

cups of black tea with a little milk and sugar, form a salutary and agreeable wash for the stomach, and serve to remove all acrid materials, left undissolved by digestion, and which if not carried away might disturb that rest, for which the appropriate hour now approaches. It may be added that tea is nutritious in a degree, as well as a diluent. Liebig has shown that its peculiar constituent, theine, is an azotized principle of a highly plastic nature, and chemically almost identical with the analogous principle of coffee (caffeine). The observations of Dr. Böcker further show that both tea and coffee retard the destruction and waste of the tissues of the body; so that by their aid a person can subsist on less food without losing weight, than one who drinks water only. This accounts for the well-known invigorating and refreshing influence of tea and coffee.

644. The practice of dining early, at from one to three P.M., which is pursued by the majority of persons in the lower and middle ranks of society, would deserve more general adoption on the score of health, were it not generally impossible then to devote the time to it, and to rest after it, that the principal meal requires. A hurried early dinner, if plentiful enough to satisfy the appetite, is pretty sure to cause indigestion, and disqualifies for exertion afterwards. If, on the other hand, it be purposely made light to avoid this, it may not suffice for the wants of the system, and so an evening meal or supper becomes necessary. The chief objection to suppers is that they are indulged in either so freely or at so late an hour, that primary digestion is not accomplished by bed-time. Hence flatus and other symptoms of indigestion occur on lying down, and prevent or disturb sleep, and the individual rises on the following morning with a pasty mouth and unrefreshed. To avoid these consequences, the supper should be taken at least two hours before going to bed; and should consist of such light materials as are easy of digestion, not too bulky, and not disposed to generate flatus. Those who use much exercise may take with advantage a little light meat, chicken, game, white fish, or eggs, with a small quantity of wine and water, or sound beer (if this do not disagree). Those who require less sustaining food, as for instance sedentary, plethoric, or inflammatory individuals, will find a more suitable supper in a light farinaceous pudding, bread and milk, or oatmeal porridge; the last is especially useful in persons of costive habit. A few cur-

rants, raisins, or a little apple added to farinaceous puddings serve to counteract their constipating tendency.

Regularity in the hour of the meals is of great importance to the preservation of health. The stomach acquires the habit of expecting, and the power of digesting, food at regular intervals, and various disturbances in its function and in the system result if it be disappointed. For this reason it is best for those who cannot always dine early, to keep regularly to the late hour. The evil effects of long fasting are partly dependent on the infraction of this rule; but some of them really result from inanition, as has been noticed under the head of causes of disease (§ 63). Few delicate persons can bear much exertion of body or mind before breakfast: the practice of taking an early morning walk is only suited to the robust, who have fed largely and late on the preceding day. When it is borne in mind that food is intended not only to support the slow process of nutrition and reparation of the textures, but also to afford materials for the immediate protection of the blood against the chemical influence of the oxygen absorbed during respiration, and to guard the stomach against the chemical action of the gastric juice, the injurious tendency of long fasts becomes at once apparent, and this tendency is the more marked in proportion as small capacity in the digestive power limits the quantity of aliment that can be rendered available at any one time.

CLOTHING.

645. The acknowledged purpose of clothing, viewed as an influence in preserving the health, is to maintain, as far as possible, such an equal warmth of the surface and extremities of the body, as may conduce to the comfort of the feelings, and may promote a free circulation, perspiration, and innervation in all the external parts of the body. But the healthful operation of clothing is not altogether confined to its property of retaining warmth. It is useful also in protecting the body against the injurious influence of external heat, dryness, moisture, and electricity. Various modifications of the clothing serve best to secure these ends under different circumstances.

The lower animals exhibit many interesting facts illustrative of instinctive or natural provisions for varying their clothing, to suit

differences in season and weather; from some of these we may derive useful instruction. The change of coat in horses takes place in spring and autumn, at times which depend to a great extent on the character of the season; the thick winter coat being slow to come off in a cold spring, but being soon shed in continued warm weather: so likewise cold weather in the autumn accelerates the thickening of the coat, which in horses left to nature we find abundantly provided *before* the severity of the weather is established. Sheep change their wool only once in the year; but its rapid increase before the winter sets in, and its tardiness in loosening and falling off until June, when all the cold winds of the spring have passed by, afford useful suggestions as to the propriety of anticipating the cold by the protection of additional dress, and of patiently awaiting its subsidence before that protection is laid aside. Birds moult their feathers early in the autumn; the new plume then thickens in down as the winter sets in. In the spring many of the downy feathers drop off, and are, in some tribes appropriated to the lining of their nests: through the summer the feathers continue to get thinner until the moulting season, when all give place to the new plumage in their turn.

But attentive observation of the appearance and habits of animals detects further contrivances whereby the same coat or plumage is caused to vary in its protective power with changes of the weather as well as of season. Thus cold determines a partial erection (§ 120) of hairs and feathers, which has the effect of increasing the thickness of the covering which they form, so that this retains more air in its interstices, to the augmentation of its non-conducting and protective power. On the other hand, warmth occasions hairs and plumage to lie close and smooth, so that they form a thinner investment, which permits the more ready escape of heat. Horses, which are exposed in the winter, often roll in the dirt and mud, and this concreting in their coats gives them a thickness and capacity to resist the outward passage of heat, which it would be unwise to deprive them of by the process of grooming. Hence curried horses require artificial clothing. The feathered tribes generally are protected from wet by their imbricated plumage, which is rendered more effective by the drooping direction which they give to their feathers and tails when exposed to rain. But they are supplied with another means of rendering their clothing waterproof, in the oil with which their feathers are im-

bued. In aquatic birds this dressing is so abundantly supplied by the skin itself, that the plumage scarcely ever becomes wet. In other families there is less fat in the integuments; but the defect is remedied by the instrumentality of a large oil gland situated above the tail, and to which they instinctively have recourse when pluming and dressing their feathers. It is very interesting to observe how domestic poultry spend the greater part of a wet day in this occupation of inunction, which is no doubt a luxurious as well as a useful one. Another habit, contrasted with the preceding, may be noticed in the same birds in warm dry weather; that, namely, of throwing dust or ashes into the plumage; perhaps the object of this is to remove any superfluity of oil, or it may be only to relieve the irritation produced by vermin, with which they are always infested. Some land birds, more rationally, delight in washing under the same circumstances.

The preceding facts are not devoid of instruction in regard to the management of the dress of human beings, who learn to cover their nakedness under the guidance of experience and reason, which are better or worse guides than instinct, accordingly as they are well or ill employed. It says little for the boasted superiority of man's reason, if it do not lead him to adopt means more effectual in resisting the hurtful action of temperature and external influences than those which are matters of instinct with the lower animals; and yet there can be little doubt that none of these suffer from cold, wet, and atmospheric changes, to the degree that human beings do. This is because reason and common sense are too frequently set aside by foolish habits, originating in vanity, fashion, caprice, prejudice, indolence, or ignorance, and disease and infirmity are the penalties that are paid for the folly.

The most convenient and concise plan of practically dealing with this subject of clothing will be to consider the way in which the physical influences that injuriously affect the body may be best intercepted by articles of dress.

646. We guard against external *cold,* by covering the body with such materials as by their low conducting power and thickness prevent the undue escape of animal heat. The most effectual for this purpose are furs and woollen fabrics; next rank thick spongy silk and cotton stuffs; and the lowest of all are linen cloth, and silk and cotton webs, which when very thin lose nearly all their

protective property. The porosity of furs and woollen garments is also valuable in consequence of its permitting the escape of insensible perspiration, and on account of its lightness; but it impairs their protective quality against strong *currents of cold air*, especially if this be either very *dry* or very *damp*. Cold air in strong motion penetrates woollen stuffs of considerable thickness, and carries with it a dry or a damp chill according to its hygrometric condition. In this penetration it is probably aided by the law of gaseous diffusion, which comes into play whenever there are different amounts of watery vapour in air (§ 72). This consideration accounts very well for the peculiarly chilling influence of a desiccating east wind and of a cold fog; the interference of both with the cutaneous perspiration, and with the circulation, explains most of their injurious operation. The best protection against these agents, is afforded by leather or even by the more impervious textures, such as India-rubber cloth or oil-cloth; but these should not be worn too near the skin, lest they should prevent the proper escape of its perspiration, and cause an unhealthy dampness of the surface. Chamois leather may be used as a waistcoat over one made of flannel; and the still less pervious textures may be employed either in detached pieces, as in the piline and India-rubber chest protectors, or loin-belts, or as outer garments in Mackintosh capes, cloaks, and overalls, but these should be provided with ventilating apertures wherever convenient, to permit the free escape of the cutaneous exhalations. In this way may be imitated in a degree the clothing of birds, which are much exposed in their flight to cold winds, damp or dry; their plumage being porous and downy underneath, but denser and impervious externally, whilst the overlapping of their feathers leaves a free escape for the exhalation from the skin. A similar advantage is obtained to a smaller extent by using several garments of different degrees of permeability, the warmest and most porous being worn next the skin, and the others externally; this alternation of successive layers of different qualities increases the non-conducting properties of clothing, and diminishes the penetrative power of cold and damp. There are very few instances in which flannel or fleecy hosiery does not form the best under dress during at least eight months in the year in this country, and a thinner material of the same kind, or merino (a mixture of wool and cotton), answers very well during the remaining four. The

exceptions occur with persons of very irritable or relaxed skin, for whom an elastic cotton or spun silk material is more suitable. Warm under-dresses should not be worn in bed, as they then are apt to relax the skin too much, and to render it more susceptible to the impressions of cold during the exposure of the day. Calico is the best material for the night dress; any additional warmth required being afforded by bed-clothes. It is of great importance to maintain the warmth of the extremities; there are few who can safely dispense with woollen stockings in the winter months; and those who are liable to coldness of the feet should also wear flannel or merino drawers, and flannel linings to their shoes and boots.

647. Some of the kinds of clothing best suited to protect the body from *wet* and *damp,* are such as have already been mentioned as preventing the penetration of cold winds. For the exclusion of wet they should be worn outside of all other clothes, for the sake not only of permitting a freer escape of perspiration, but also of excluding moisture from other parts of the dress, for although the wet may not reach the body, its proximity may chill by evaporation. For the same reason the cardinal rule of keeping the feet dry is better accomplished by outer coloshes, gutta-percha soles, varnish, and other like expedients, than by inside cork soles or oil-silk socks, which allow the leather of the boots or shoes to be soaked in wet, and only intercept its contact with the foot.

648. The change from winter to summer clothing should be made gradually and with great caution; and it is better to be tardy than hasty in change. The fitting period varies in different seasons, but it rarely occurs before the month of May, often not until June; for although there may be warm weather earlier, it is generally of brief duration, and is alternated with bleak winds which render the spring months peculiarly trying, and often cause more illness than all the continued severity of the winter. Much of this mischief is to be attributed to the too early change of dress (§ 645). The converse rule may be applied to the change at the end of the summer; which is most prudently made in anticipation of the permanent cold. Many of the autumnal diseases arise from the great variations of temperature that then obtain between day and night, and from sudden changes of wind, and these take the more effect in consequence of finding

the body relaxed by previous heat (§ 25, 81), and yet protected by only summer clothing.

649. In this country even in summer the clothing is required to maintain sufficient warmth, rather than to exclude heat; but it may now be reduced to the thinnest and lightest materials, a slight woollen or cotton fabric being retained next the skin, to prevent the chilling dampness of the linen when wet with perspiration. Frequent changes of linen, where practicable, supersede, to a great extent, the need for this precaution, and together with free ablution, are very wholesome and refreshing during intense heat. Protection against solar heat and hot air is best afforded by loose linen vestments of light colour, large straw hats, bonnets, veils, and other like expedients, which it is unnecessary to particularize.

650. It is very probable that atmospheric electricity may exert an influence on the health, which may be in some degree counteracted by modifications of the dress. Thus silk vestments have a considerable protective power in consequence of their property of non-conduction; and if worn next the skin, they may possibly excite electrical disturbance, which is supposed by some practitioners to operate as a hygienic agent, with persons disposed to rheumatic and nervous diseases. Further careful observations are, however, needed to determine these points.

651. Under particular circumstances or conditions of the system, additional warm clothing is necessary; for instance—in infancy, when the calorific power is low; in old age; in convalescence from acute diseases; during fatigue and other states of weakness; in organic diseases of the heart, when the circulation is feeble; in case of privation of food; during the operation of purgative or diaphoretic medicines; and when circumstances prevent the use of a proper amount of exercise. Under the influence of these conditions, a feeling of chilliness arises, particularly on the surface and in the extremities, and this is an indication of the need of more clothing; and if this be put on to prevent the sensations of cold, it will often counteract such disturbances of the circulation and internal congestions as the weakened body is liable to at the time (§ 79, 292), which too often lay the foundation of future disease.

No part of the frame requires the protection of clothing so little as the head and face. The final cause of the comparative freedom

of these parts from the bondage of garments is obvious, for unrestricted communication with external space is necessary for the senses, breath, speech, and nourishment. The physiological reason for the greater power of the head to resist cold, may be probably found in the larger size and less varying calibre of its blood-vessels (§ 266), which even in weakened states of the circulation supply an amount of blood that may cause a sense of heat and fulness when other parts are suffering from the opposite feeling (§ 330, 331). But even for the head, during exposure to the air and during the night, it is expedient to use such light covering as may prevent any check to the perspiration of the surface, or to the ceruminous secretion in the ears, the proper continuance of which is essential for the preservation of hearing. I do not, therefore, altogether approve of the favourite modern practice of discarding nightcaps, and I have known it to induce catarrhal affections of the eyes and nose, earache, and deafness. Those who are prone to suffer in this way, or from dryness of the scalp, may find much benefit from wearing at night an oil-silk cap over a thin nightcap.

Various other cautions and directions with regard to clothing are sufficiently indicated upon principles of common sense—such as the frequent changing of garments, especially under ones, for cleanliness sake; the avoidance of all tight ligatures, lacings, or buttonings, which can cause improper pressure on any part of the body, and interfere with free motion, circulation, and perspiration. The invention of India-rubber web and other elastic materials has supplied a valuable means (not used so generally as it deserves) of avoiding these evils, and of yet maintaining the due apposition and attachment of the various articles of dress.

AIR AND TEMPERATURE.

652. The influence of impure air in causing disease has already occupied our attention (§ 72, 73): we now have to specify what are the states of the air that are most conducive to health; and inasmuch as temperature chiefly operates by being conveyed through the air surrounding the body, it will be convenient to include a few remarks on this topic under the same head.

The invigorating effect of fresh air may be partly referred to

its superior purity more perfectly adapting it to the work of respiration; but some of its refreshing power is due to a direct influence exercised on the nerves and capillaries of the surface of the body, and through them on the functions generally. This is exemplified in the reviving power which a current of fresh air or fanning exerts over persons in a state of faintness, and this result is the more remarkable when the air is cool and the body has been previously weakened by heat and confinement, but the long-continued action of a cold current under these circumstances is highly hazardous. The less marked, but more enduring, benefits of fresh air are experienced in rides, drives, and other out-door exercises, passive or active, which are universally acknowledged to be essential to the maintenance of the bodily health. To obtain the greatest amount of good from these airings, it is advisable not only to resort to localities where the air is most pure and free from contamination, but also to vary its qualities in other respects. Thus the inhabitants of valleys derive benefit from the air of hills; those of inland places, from that of the sea; and residents on the sea-coast find advantage in drives inland. For a similar reason, great improvement often results to the health from continued travelling by land or sea, and although this comprises other hygienic influences, besides change of air, experienced travellers rarely fail to distinguish this as being of sensible efficacy, and exercising a marked effect on the vital functions. Similar beneficial results sometimes ensue from gentle and favourable changes of weather, which bring altered states of atmosphere even to our own homes. It is by no means certain on what physical properties depend the all-varying hygienic influences of air in changing weather and different localities; but it may be useful to notice somewhat of the direct operation upon the body, of the different states of *dryness* and *moisture, temperature* and *purity in the air.*

653. A very *dry* air exerts the physical influence of causing rapid evaporation and of exciting a high degree of electric tension; the resulting operation on the functions is generally more or less stimulating. The tonicity of the textures is usually augmented by it, whilst the desiccating, and probably also the electric action of the air on the cutaneous and mucous surfaces, induces an excitement which is beneficial in persons of relaxed and leucophlegmatic habit; but which in the irritable and sanguine, may lead to inflam-

mation or fever. A very dry air, the effect of which is increased both by heat and motion, impairs the perspiring power of the skin, and produces various kinds of cutaneous inflammation, often with the addition of fever and thirst. To a moderate extent, and with a mild temperature, dryness of the air is salutary, facilitating as it does the purification of the blood in the lungs (§ 72), improving the tone of the motor fibre, checking tendencies to excessive secretion, and counteracting various septic processes both within and without the body, which are promoted by humidity. We formerly had occasion to notice that dryness of the air is one of the surest safeguards against the activity of miasmatic poisons (§ 83). Another reason why dry air may be deemed the most healthy, is because the injurious operation of dryness can be more efficiently counteracted than that of moisture. A judicious use of bathing (warm or cold), exercise and friction, which by inducing gentle sensible perspiration remove the dryness of the skin; the prevention of too rapid an evaporation from the surface by inunction, emollient applications (especially glycerine), and difficultly pervious coverings, such as oil-silk, and leather, applied to parts which suffer, generally succeed in obviating its hurtful influences without interfering with its salutary effects.

Dryness of the air is best secured by connexion with a light porous soil, like sand and gravel, into which the water of rain and dew speedily sinks deeply; or with hard rock, from which it drains away or evaporates. The nature of the subsoil is therefore of the greatest importance in so far as it determines the character of the air in any locality. A declivity, or an undulating surface, and a freedom from dense foliage and very luxuriant vegetation, also contribute to the dryness of a neighbourhood, and generally thereby to its salubrity. Dryness of the air is further, in this hemisphere, associated with the prevalence of certain winds, especially those from the east, the aridity of which is due not only to the much rarer occurrence of rain whilst they last, but also to the smaller proportion of dissolved moisture which they contain. And because such winds prevail more both as regards strength and frequency in the eastern than in the western portions of the British Islands, the former have for the most part a drier climate than the latter. But easterly winds have other qualities superadded which detract considerably from their salutary influence on the animal frame, and often prove positively injurious. Thus the north-east and due

east winds are characterized by bleakness and penetrative coldness (§ 646); and except in persons whose circulation is naturally strong, and in whom this is kept in activity by exercise, their tendency is to check the passage of the blood through the surface and mucous membranes, and to impair the functions connected therewith. The east wind generally abounds in ozone; and this may be one reason of its irritating action on the mucous surfaces. The general objection to exposed situations on account of the capricious and changeable character of the winds, applies therefore with peculiar force to such positions as have an eastern aspect, for there the transition is more than usually sudden and extreme on account of the power and bleakness of the returning cold.

The south-east wind is also dry, and in winter and spring differs from that which blows more from the north in being of milder temperature; but as summer advances it becomes remarkable for its sultry and oppressive quality, which in south Europe is expressed in its highest intensity in the *sirocco*. Much of the overpowering influence of this is due to its desiccating qualities, (manifested not only in animals by the thirst and feverish dryness of the skin and mouth, but also in plants and trees by the drooping of their leaves,) combined with the general relaxing agency of heat on the vascular fibre, by which the powers of the circulation are enfeebled, and the purifying processes of respiration and secretion are more or less impaired. But doubtless something of the peculiar effects of a south-east wind is due to electric tension; and in this country their most marked manifestation generally precedes the occurrence of a thunder storm; nor should the fact formerly mentioned be forgotten (§ 92, note) that it is especially during the prevalence of this wind that the air becomes surcharged with animalcule tribes, and that certain epidemic diseases, as for instance Asiatic cholera, and occasionally influenza, make their greatest progress.

654. A damp or moist air, irrespectively of its temperature, may be considered to be lower than dry air in its vivifying power, inasmuch as it contains less free oxygen, and has a lower diffusive capacity to aid it in pervading the lungs during respiration. The greater facility which it affords to processes of decomposition and infection has also to be set against its salubrity in other points, besides some particulars in which it is contrasted with moderately dry air. Warm moist air is universally relaxing (§ 25, 123), and excepting in persons of dry skin and over-braced

vessels, it is oppressive and debilitating. Under its influence, perspiration accumulates on the surface, perpetuating the relaxation so long as the warmth continues, and chilling and impairing the circulation and excretion if cold ensues; the very evaporation from the moistened surface, may under such circumstances cause an injurious chill. Cold damp air, which is proverbially unhealthy, is more certainly pernicious, and its disordering action may be in great measure traced to the physical properties whereby it is made to abstract heat and electricity, and to check perspiration and assimilation. Hence ensue the retention of lactic acid in the circulation, the formation of oxalic instead of lithic acid, and the imperfect elaboration of the blood-plasma; these aberrations from the normal chemistry of the body, often manifest themselves in the shape of various diseases of the blood and circulation, of which rheumatism, neuralgia, certain cutaneous affections, cachectic ulcers, tubercles, and scrofula, are familiar examples.

The most common cause of dampness in the air is the retention of moisture on or near the surface of the soil, such as occurs in low grounds in which clay prevails, in which water accumulates or is imperfectly drained off, and in which evaporation is retarded by the shade of thick trees, or of high rocks or hills. But independently of soil, a house may be damp in its own materials, which from recent construction, or from their tendency to attract and precipitate humidity (as is the case with limestone or marble), may constantly impregnate the air with moisture. Wet weather and damp winds, such as the south-west, are less injurious causes of humidity, because they are less permanent; but their influence is often obnoxiously manifest during their continuance, and always most so in localities that are damp from other causes. The air of the sea-side, even on the south-west coast, although generally abounding in humidity, is far less injurious than that of damp places inland; probably because much of the sedative and chilling operation of the moisture is in this case counteracted by the stimulating influence of the saline particles that are associated with it. The different effect produced by a sea fog, and by a land mist, is familiarly known.

The hygienic directions which are calculated to prove serviceable with regard to moist air are chiefly such as relate to protective or counteracting influences. Artificial heat is the most convenient and efficacious desiccating agent within our reach; and if com-

bined with adequate ventilation, it may be made to do much to remedy dampness of air within doors, whether arising from the soil or from the building. In warm weather, when fires are unpleasant, much unhealthy moisture may be removed from the air, by so adjusting the doors and windows, or air holes, that ventilation may be secured without opening apertures towards the dampest side of the house. In limestone districts, good may be secured by keeping large pans of quicklime in the apartments, especially those of the basement and ground-floor. This expedient, for reasons previously mentioned, is also a serviceable precaution against malarious and infectious influences; its utility in preventing meat from becoming tainted in a damp larder has long been known.

Much may often be done to diminish the dampness of clayey and marshy soils in the immediate vicinity of dwellings, by adopting an efficient system of covered drainage; by effecting the removal of superfluous trees and shrubs; and, where practicable, by covering the surfaces which are most constantly wet, with light sand, gravel, brick and mortar rubbish, or some similar light and porous material, which is capable of forming an artificial superstratum that can intercept the moisture of the damp ground. The insalubrity of many low parts of the metropolis, especially in Pimlico and Westminster, has been wonderfully diminished by expedients of this kind. Protection against the damp of limestone walls of houses is obtained in a similar way by the process of battening, that is, lining the wall with wood and canvas, or lath and plaster. The free use of concrete, or of slate or metallic plates, in the foundations of houses, so arranged as to prevent the rising in the walls of moisture by capillary attraction, should never be neglected, particularly in damp localities, where the lower parts of the building are likely to be inhabited.

655. The subject of *temperature* has been so frequently touched upon already, that it would be a work of superfluity to dwell long upon it here. The mean temperature that is most generally conducive to comfort and health is about thirty-five degrees (of Fahrenheit) below the heat of the interior of the body: that is 63°; blood-heat being 98°. It is rarely expedient to sustain an artificial temperature higher than this; for the invigorating properties of the air suffer at more elevated temperatures, so that if more warmth is needed than is retained in the body at this point,

it should be ensured by additional clothing or other means. The advantage of keeping the atmosphere of apartments considerably cooler than the body itself consists not only in the greater amount of oxygen that is then contained in a given bulk, but also in the greater force with which the warm foul air of respiration is carried away from the breathing passages, and a pure medium supplied to them in consequence of the difference of temperature maintaining a current. Overheated rooms are peculiarly oppressive, for the converse reason, unless the air be continually changed by efficient ventilation; and rooms warmed by stoves or heated air, cause a feeling of closeness which does not result from open fire-places, because these latter communicate heat chiefly by radiation, and leave the atmosphere comparatively cool. The animal body being naturally much warmer than the surrounding air, operates as a ventilator for itself, by the same consummate adaptation of pneumatic laws as that which supplies a flame or fire with a continued current of fresh air; just as a fire burns brighter and clearer in frosty weather, so an animal breathes a purer denser air at the same time, which if not injurious by its cold, is refreshing and invigorating to the body. Not only healthy and robust persons, but also some who are asthmatic or otherwise weak in respiratory power, acquire increased strength and energy in clear cold weather; and even those, who from weakness of circulation cannot resist continued cold, and usually require a mild atmosphere around them, are generally refreshed and benefited by breathing cold air for short periods, whilst exercise and warm clothing protect them against its sedative and chilling effects.

656. Artificial heat is most needed by young infants and very aged persons; in them the intrinsic calorific power is too low to bear safely even the temporary exposure to wintry air, just mentioned as useful to some weakly subjects. So too, those who suffer in the lungs and air passages from even brief impressions of cold, which is the case with the greater number of pulmonary invalids, should not venture into the open air during inclement weather without the protection of a respirator, which acts as a kind of clothing to the air passages; and although it detracts from the refreshing coolness of the open air, it does not materially impair its purity. I have also known this instrument to prove useful to anæmic subjects and others with low calorific powers, not merely by its protecting the air passages, but also by its retaining

and economizing heat which is generally expended with the expired air.*

657. The absolute necessity of maintaining the purity of air that is respired, by continual change, has been repeatedly alluded to (§ 72). In cold weather this change is mainly promoted by the difference of temperature that exists in the air heated by respiration or by the fire of a room, and in that of the external atmosphere; the increased ventilation thus insured has been specified as one cause of the more invigorating properties of the air in winter. In hot weather, on the other hand, and in apartments that are heated by convection, more than by radiation, it is necessay to provide means to assist the motion of the air. In summer this may usually be effected by opening windows and doors; and the close smell which shut-up rooms acquire in that season generally suggests this remedy. In India and other hot climates, where even the outer air is so hot and still that it supplies no movement, machines are used for creating a current of air, and it is further cooled by evaporation from a moist surface. Even the sprinkling of floors and walls with water is useful, not only by cooling the air, but also by secondarily promoting its motion. In very sultry weather dining rooms or other apartments may be kept refreshingly cool for evening use, by hanging a canvas blind, saturated with water, outside of the window, and by keeping it sprinkled from time to time.

In cold weather some degree of ventilation is necessarily insured by the fires employed for warming rooms; but it is often effected in an irregular or insufficient manner; as by draughts of air under doors, and through the chinks of floors; these cause a cold current on the feet and lower parts of the body, whilst the head and breathing passages, which are above the opening of the fireplaces and the set of the current, are in a stratum of warm and

* Various expedients for retaining the warmth of the breath for the purposes of sustaining animal temperature, were long since recommended by Dr. Arnott and others. An incident in point, which occurred to myself many years since, may afford a useful hint to others in a similar predicament. I had to go a long journey on a cold winter's night; and there being no room inside the mail, I was obliged to ride on the outside, although insufficiently clothed for the exposure. Reflecting on the great loss of heat, manifested in the steaming breath of myself and fellow-passengers, I endeavoured to save a portion by entirely covering my head and face with a silk pocket-handkerchief, the lower ends of which were closely tucked inside my buttoned coat. The result was an increase of warmth, not in the face and chest only, but even in the extremities, more comfortable and diffused than an additional great coat could have produced.

less pure air. It is quite true that by the law of diffusion of gases, as well as by the force of the currents, and other accidental disturbances, a change is effected in the whole air of a room; but it is so less completely and rapidly, than is desirable for so important a purpose as the constant supply of pure air for respiration. To obviate this, various ventilating contrivances have been recommended, but none in simplicity and efficacy excel those recommended by Dr. Arnott,* which not only furnish apertures calculated in themselves to promote a continued change of air in the room, but by means of a simple self-adjusting valve, prevent the entrance of too strong a current, or the passage of one in a wrong direction. For perfect ventilation, two apertures (or sets of them) are requisite; one for the admission of fresh air, another for the escape of that which is foul. These should be placed at opposite sides of the room, and it is generally well that the outlet should be near the ceiling; it may be made into the chimney when a fire is used (a properly arranged valve preventing the influx of smoke), or when there is no fire or chimney through the ceiling or roof, or in a top window pane. When the valvular opening into the chimney is adopted, it is absolutel[illegible]ssential to its proper working, that the throat of the chimne[illegible]nmediately over the burning fire should be narrowed far l[illegible]nd what it usually is, otherwise all the air that enters the ro[illegible] by crevices and inlets especially provided, will pass through t[illegible] large channel over the fire, and there will be a tendency for mo[illegible] also to find its way in from the chimney through the valve; an[illegible] this will accordingly be kept close pressed and inoperative. The throat of the chimney over the fire, and the valvular opening into the chimney, should together only have the same area as the sum of the several inlets for fresh air into he room, then the air admitted will be fairly divided between the two outward routes. When t[illegible] arrangement is properly adjusted, the valve will be kept consta[illegible] pressed back by a steady current passing onwards into the c[illegible]ney for hours at a time, without the slightest attempt at regurgitation being made. The most suitable position to afford the freest influx of air, is near the floor; but apertures in this situation are often objectionable on account of the chill which is communicated

* *On the Smokeless Fire-place, Chimney-valves, and other means, old and new, of obtaining Healthful Warmth and Ventilation.* By Neil Arnott, M.D., F.R.S., &c. 1855.

to the feet and lower parts of the body. The inlet for fresh air may therefore be conveniently made in the upper pane of a window or the panel of a door, where these are as remote as possible from the outlet; and to prevent draughts, and to promote the diffusion of the air through the room, the opening should be covered with wire-gauze or a finely perforated zinc plate, in addition to which, if necessary, an oblique screen of wood or a curtain may be placed before it so as to direct the current to the walls and ceiling. Under these arrangements the fresh air, which is heavier, because cooler, than that within the room, gradually falls, and is dispersed, displacing the warmer foul air; and reaches the middle space cool and refreshing for the heads and breaths of the inmates, yet causing no draughts on the lower extremities. In very cold weather, it is certainly advantageous to have the supply of air moderately warmed before it enters the room; and the best method for effecting this, is the employment of a well-regulated warm air or hot water stove, or of an Arnott stove, so placed in the hall or at the bottom of the staircase, that a fresh current may be continually coming to it to get heated. This influx of gently warmed air is useful, not only by taking off the excessive chill, but also by promoting such a free current into the house as serves to supersede those irregular draughts, which, in default of other supply, force their way through every chink, hole, and cranny in the floors or walls, and which besides cold, often bring them dust and bad effluvia acquired in their passage (§ 72, 73). The extreme dryness of the air thus warmed may be obviated by placing shallow earthen pans containing water, on the stove.

658. The ventilating force that operates in all the above noticed cases is that which depends on atmospheric pressure, displacing air rendered lighter by heat; this force properly applied and directed, amply suffices for securing fresh air to ordinary dwellings. But for large public buildings in which great numbers of people are congregated, or where other causes of contamination or impurity are operative, as in manufactories, hospitals, mines, holds of large ships, &c., this force may fail to be effectual; unless when aided by extra fires and lengths of chimney, and then much care is required both in construction and in management to make it answer the object in view. The new wing of the Brompton Hospital is ventilated and partially warmed on a plan of this kind,

devised and executed by Mr. Haden, of Trowbridge, and after more than twelve months' trial it seems to answer very well. The other forces which have been applied to effect ventilation on a large scale, are mechanical powers, and the operation of a jet of high pressure steam. The latter is very efficient in creating a strong current of air, and is chiefly applicable when foul air is to be drawn off. The noise attending it is an objection in some cases. Mechanical ventilation was for a long time principally effected by the revolving fan wheel; but Dr. Arnott has shown that its propelling power is very limited; for when its revolution is resisted by any opposing force equal to the pressure of a column of seven inches of water, the motion no longer creates an aerial current, but becomes more rapid, and carries the air round with the wheel in a sort of eddy, instead of propelling it forward. This scientific physician has devised a mechanical ventilating apparatus, which in amount and steadiness of power, and of facility with which the supply of air can be regulated, excels every contrivance hitherto accomplished or proposed. Such a machine, which is a kind of pump, moved by water or by steam, and which propels air of a regulated temperature in an accurately measured quantity, has been in use at the hospital at York for some years. The chief difficulty in securing its successful operation seems to lie in proportioning the propelling force to the extent of channels and spaces required to be ventilated. It was the impossibility of calculating the latter which appears to have caused the failure of a machine of this kind at the Brompton Hospital. Dr. Arnott's plan of mechanical ventilation has been applied with success to the supply of pure air in emigrant ships.

659. But in addition to the supply of fresh air to the interior of buildings, certain other measures are often required for the removal of contaminating effluvia, especially in large towns. Systematic and scrupulous cleanliness, and an adequate and air-tight drainage are most effectual for this purpose. Some recommendations with regard to these subjects have been already made in treating of exciting causes of disease (§ 70—73). For purposes of cleansing, and for rendering habitations wholesome, an abundant supply of water is necessary; the evils of impure air are commonly experienced where this purifying element is scanty. Additional means of purification are afforded by certain chemical agents possessing the power to absorb or decompose noxious

effluvia. From the most recent observations, especially those of Dr. Stenhouse, recently prepared charcoal appears to be the most efficient of these agents, absorbing and destroying all offensive effluvia contained in the air (§ 105). Shallow dishes containing the charcoal may be conveniently placed wherever a bad odour or effluvium exists; and the efficacy of the charcoal may be from time to time renewed by heating it to redness under sand. Lime also is a cheap and useful material for the same purpose, and may often be advantageously used both by lime-washing walls and ceilings, and by pans of quick-lime kept in the basement story of houses near any source of foul air. Other disinfecting agents are still more powerful, and at the head of these undoubtedly stands chlorine, which is invaluable for its efficacy in destroying noxious effluvia, the source of which cannot be stopped. Chloride of lime, and dissolved chlorinated soda, are convenient vehicles for furnishing a constant moderate supply of the gas, and this may be extricated from them in greater quantity by the addition of a little acid whenever there is need. A cheaper plan for obtaining an abundant supply of the chlorine, is found in mixing black oxide of manganese, common salt, and sulphuric acid; the acid being added from time to time, in small quantities, throughout the day.* Under circumstances in which the operation of chlorine is too irritating, nitric or acetic acid vapour may be substituted, but they are less effectual, and must be used in greater quantities. In houses in which unmanageable drains or immoveable cesspools unavoidably taint the air, some of these disinfecting agents should be kept in perpetual operation.†

BODILY EXERCISE.

660. The want of exercise has been noticed as both predisposing to, and exciting disease (§ 24, 65); and the opposite extreme, excessive exertion, has also been mentioned as equally detrimental in its effect on functions and structures (§ 64). As a hygienic

* A cheap and convenient apparatus for fumigating with these materials has been contrived by Mr. Smith, of White-street, Borough, and may be obtained of Horne and Co., 123, Newgate-street.

† The consideration of public sewerage and of other matters connected with these topics, is far too extensive to be entered on here; but the reader will find much valuable information in the various Reports of the Sanitary Commissioners, and of the Health Officer of the City of London.

agent, therefore, exercise should be between these extremes; and its utility and importance will be proportioned to the regularity and discretion with which it is practised.

Moderate and sustained exercise in healthy air by walking, or riding on horseback, and during various out-door occupations and pastimes, excites into activity most of the functions of the body, especially the circulation and respiration, and those other actions intimately connected therewith, namely, secretion and the production of animal heat; and, provided the fatigue or exhaustion resulting from the excitement be adequately removed by sufficient rest and sustenance, the vital functions gradually gain vigour by activity, and the structures concerned in their support acquire a fuller and healthier development. The muscles especially, including the heart, manifest an increase of strength and firmness; the blood-vessels are improved in tone, so that they distribute vigorously and equalize the flow of blood, and prevent partial congestions and obstructions; and the blood itself thus energetically carried through the organs and textures, undergoes the complete series of changes from nutrition, purification, and arterialization, by which its integrity is maintained, and by which it is adapted to sustain the several functions of the body. The appetite, the digestive powers, the intestinal action, the warmth of the surface and extremities, the spirits and temper, are generally all improved by habits of regular exercise:—what more could be said to recommend any hygienic agent? But since much of these beneficial effects depends on the judicious manner in which exercise is suited in kind, time, and degree, to the strength, habits, occupation, age, sex, and other circumstances of the individual, it may be as well to particularize a few cautions and directions in regard to the most important of these points.

661. In childhood, youth, and early maturity, when the joints are supple, the textures in full elasticity, and the whole frame fitted for quick and varied movements, diversity and activity of muscular action are suitable and salutary; and there is pleasure as well as benefit in practising feats of agility and strength, which call into play all the muscles of the body, such as running, leaping, climbing, wrestling, rowing, and the athletic games of cricket, fives, tennis, quoits, &c. But at this youthful age there is less power of enduring continued fatigue than in maturer life, and the body more absolutely requires repose after exertion. The health

of young persons, especially of the female sex, is often greatly injured by too long walks, especially if frequently repeated, whilst they suffer comparatively little from greater exertion for short periods, as in dancing, or riding on horseback. In adult age, on the other hand, prolonged steady exertion is better borne than exercises requiring great agility of movement; and unless youthful mobility has been preserved by constant practice, more sober and steady motions are more fitting to the sedate age. Exercise on foot and on horseback is the ordinary mode, except among the working classes, whose occupations engage them of necessity in various kinds and degrees of muscular exertion: and in all these experience teaches long before the period of middle age, that more work can be safely and comfortably effected by steady and sustained exertions, than by sudden or rapid efforts. But it does not therefore follow, that the exercise taken for the sake of health in middle age should be monotonous or slow. Persons who are principally engaged in employments either sedentary or confining them within doors with little exertion, would feel little benefit or refreshment from the hour or two which they can spare for out-of-door exercise, if it were passed in mere sauntering or strolling on some unvaried road. A brisk walk, diversified as much as possible in direction, including, if possible, ascents and descents, and away from the vicinity of the smoke and effluvia in which the rest of the day is spent, and alternated when practicable with an inspiriting ride on a free-paced horse, or with active gardening, or some like pursuit, will most profitably fill up the time which the middle-aged man of business can devote to exercise, and will soon prove itself to be a very safe and remunerating investment of such leisure. On the other hand, he, who forgetting what becomes his age, relishes no exercise but such as is associated with the excitements of the ball-room, the cricket ground, the rowing match, or the hunting-field, speculates with a capital of mobility and elasticity which he most probably does not possess, and although he may sometimes be able to boast of a successful result, in the recovery of activity and health lost through previous habits, he yet encounters a perpetual risk of breaking down under the unusual strain to which he subjects his frame, and he gains none of that gradual renovation and invigoration which result from more moderate exercise regularly practised, and varied from day to day. In old age the sphere of exertion is still further limited by func-

tional and structural changes that have been already alluded to (§ 48, 546), and exercise, to be salutary, must be still further restricted in degree and variety. Gentle walking or riding on horseback may be safely practised by many, even far advanced in years; and carriage exercise (such as it is, which is scarcely any) remains for the more infirm. The selection of the particular mode, and the determination of the extent, in which exercise may be beneficial in any given case, should depend very much on the previous habits as well as on the present condition of the individual. If a man has lived a sedentary life, and has become stiff and prematurely old in consequence, this is not the time to commence habits of activity, which would endanger the integrity of his vegetating or mineralized structures (§ 543—6). A similar caution applies to those who have lived *too fast*, and by various excesses and undue excitement and strains, have exhausted their vital powers and accelerated the degenerative changes in their textures: such persons manifest by their feeble and tottering gait, and by breathlessness on exertion, an inaptitude for exercise, which should be their warrant for not attempting it. Carriage airings and gentle frictions of the surface and extremities are here the best substitutes. The case is altogether different with those, who, by a temperate and judicious mode of living, and by habits of activity proportioned to their strength and age, have economized their vigour, and given fair play to their constitutional powers: these may be said to enjoy a green old age, in which moderate exercise continues to be not less a source of recreation and comfort, than a means of sustaining health: but even these fine, and in all respects venerable specimens of humanity, sometimes need professional warnings against presuming too much on their hitherto well-husbanded strength. They are often carried off by acute attacks, brought on by their stepping out of the sphere of safety, which although wider than usual at their time of life, has nevertheless its limits, which the steady hand of time is daily narrowing, but in so gradual and imperceptible a manner, as to escape the attention of their own mental powers, now also on the wane. One act of imprudence in advancing age may be followed by fatal results; and that may be deemed to be imprudent which in any material degree transgresses the bounds of accustomed habits.

662. The periods at which exercise is most salutary, in relation

to meals, occupation and repose, are commonly those when the bodily powers are not depressed by fasting, fatigue, or wakefulness, nor oppressed by the process of digestion. Exercise before breakfast is suitable only to the robust, and those who have fed late and largely on the preceding day: delicate persons commonly become faint from exercise at this time; and others who do not suffer so far, yet lose a portion of the appetency and digestive keenness which render the meal agreeable as well as useful, and consequently are more languid during the early part of the day. Shortly after breakfast is commonly a very good period for exercise: this meal is sufficient to remove the squeamishness or faintness apt to arise from an empty stomach, yet it is not, or should not be, so heavy as to oppress the bodily powers, or prevent their capacity for moderate muscular exertion. Those who can command the time, will find it advantageous to intersperse their sedentary occupations with short periods of exercise, taken if possible in the open air; if these be only for ten or fifteen minutes, once or twice in the course of the forenoon and afternoon, they will contribute considerably to counteract the bad effects of confinement, and by giving a fresh impulse to the circulation and respiration, will remove congestions, cool the head, warm the feet, and thus refresh both body and mind. For similar reasons it is well that more extended exercise should be taken twice rather than once daily, the second period for it being after an early tea, or before a late dinner, according to the arrangements suggested when speaking of *Food* (§ 643-4). Persons whose daily occupations are fatiguing either to body or mind, and who are obliged to dine late, may not have strength sufficient to bear the second exercise before dinner; but they may be enabled by an hour or two of rest after this meal to take an evening walk, which will then prove to be well-timed and refreshing, especially in the summer. Under all circumstances it is of importance to avoid great fatigue both immediately before and after dinner. For this being generally the principal repast, needs more than the other meals, the undisturbed energies of the system for its digestion; and if either the body be exhausted by exertion beforehand, or its energies diverted from the digestive organs by exercise taken soon after the meal, the digestion will be disturbed, and various evil consequences may ensue. It is the chief objection to very late dinners, that after the toils of the whole day, the body

is too much exhausted for the work of digestion, so that stimulants are needed to aid in the process, which they can only do irregularly and imperfectly.

663. The weaker or more delicate the individual is, the more necessary are the above-mentioned cautions against excessive or ill-timed exercise. The interval that should be devoted to bodily recreation varies considerably with the strength and habits, and with the kind of exercise used. Females and delicate persons will rarely benefit by more than half an hour or three-quarters of an hour's walk, or double those periods of gentle horse exercise: but robust males may find advantage in a considerably greater amount.

664. Exercise varies in effect according to its kind. Walking, although it gives some action to most of the muscles of the body, chiefly exercises those of the lower extremities; and by increasing the circulation and perspiration especially in their direction, it tends to derive from the head and chest, and to relieve congestions of those cavities. Riding on horseback causes more exertion to the loins, and by the regular movements which it communicates to the viscera of the abdomen, pelvis, and thorax, promotes circulation and functional activity in them: it is not equally effectual with walking in equalizing the circulation in the head and extremities, and in cold weather especially it often causes headache, but this may generally be prevented by taking measures to keep the feet warm.

Some sorts of exercise which include alternate stooping and raising the body, such as are involved in digging and other occupations of the garden, are serviceable in promoting the action of the bowels and kidneys; the same remark applies to various games of bowls. Rowing has the advantage of very generally and uniformly exercising the muscles of the whole body; but unless it be practised with moderation, the simultaneous pressure which it exerts on every part may prove injurious by overstraining the organs of circulation and respiration (§ 64); and many instances have come within my observation of the evil consequences of boat-racing.

MENTAL OCCUPATION.

665. Under this head may be comprised a few remarks upon the mental influences that are most conducive to the maintenance of health. As with the corporeal functions, so with the mental, a moderate and equable activity, with some diversity of excitement and relaxation, contributes to their well-being; and, inasmuch as the body is greatly under the influence of the mind (§ 66), the health of both is therefore equally promoted. The kind and amount of mental exercise that is advisable varies according to the different circumstances of age, sex, temperament, capacity and habit. The topic is indeed far too wide to be comprehended within the very cursory glance that can be given to it here, and it must suffice if some of the variations of mental discipline that are adapted to these different circumstances are briefly noticed.

666. In infancy the sentient and perceptive functions are active, and the emotional feelings lively, whilst the higher moral and intellectual faculties are comparatively imperfect. Hence the sensitive excitability of this age, so frequent a cause of disorder; and which so commonly needs to be moderated by various soothing expedients, such as gentle and lulling impressions addressed to the senses, and timely resort to amusing toys and other objects capable of diverting the attention and gently exercising the organs of sense and perception. But as infancy passes into childhood, there is sufficient development of moral feeling and understanding to furnish higher powers of control and direction; and although at this age it is equally necessary to avoid whatever excites fretfulness and passion, principles of self-control and patience should now be carefully inculcated by moral and religious instruction, enforced by the example of consistent kindness and justice on the part of those who manage the children. The mental as well as the bodily faculties at this early age have no strength of endurance; they are soon fatigued; and nothing can be more hurtful than their excitement in too high a degree, or for too long a continuance, by games, or scenes of amusement: exhaustion, fretfulness, and bodily suffering, are the common consequences of such excesses, and disease not unfrequently follows. A similar objection may be urged against too early or too prolonged attempts to educate the mind: such attempts anticipate the period at which

it is intended that the power of concentration and sustained attention should be acquired. Children who are precocious in intellect gain this power early, but this is itself a reason against intellectual exercise, for it then the more readily tends to strain the active faculties to a morbid degree.

667. As the mental capacity becomes enlarged by judicious training in ripening youth, it is prepared to grapple with longer and severer tasks, and in addition to the direct advantages that result from exercising the intellect by extended occupation at this age, the indirect purpose is also answered of moderating and holding in subjection the emotions and animal passions, which now acquire strength. A leading rule that should be followed in all attempts to develope and regulate the mind, is to employ its several faculties as equally as possible. The natural tendency is for those powers which are constitutionally the strongest to overrule and weaken the others, and this applies to the impulses of moral feeling as much as to intellectual capacity. A main purpose of education is therefore to prevent the inequality, by exercising the weaker powers and by judiciously restraining those which unduly predominate. Herein education includes not merely the communication of knowledge, but also the discipline of the heart and mind; the subjugation of evil and idle inclinations and propensities, and the direction of the attention, or activity of the intellect, to objects that are profitable and improving. The influences by whose aid such discipline may be exerted are manifold, but they are modified in some degree by the age and the character of the individual. In childhood, respect and love towards parents or others exercising authority; in youth, the same feelings confirmed and developed by the convictions of the understanding now conferring increased spontaneity of thought; and in all ages the constraining and elevating influence of religion, which supplies the highest motives and rules for the conduct of thinking and responsible beings;—these are the great leading instruments through which mental discipline is to be safely and effectually worked out. Other and less dignified motives are often equally powerful, such as vanity, pride, ambition, rivalry, and the like; and although these mark the falling-off of the human mind from a standard of perfection, and if not controlled may become exaggerated into vice, they may nevertheless, under proper restraint, be enlisted in the service of mental improvement.

668. When youth ripens into adult age, although technically speaking, education is then complete, the discipline and culture of the mind (which are the objects of education) should still be carried on with an energy that is proportioned to the full development which the faculties and passions have attained. This being the period at which the authority of parents or seniors is more or less relaxed, and at which the individual becomes of age to take full responsibility on himself, it is of the utmost consequence that his mature powers should be directed towards a career which will tend to promote his present and permanent welfare; and much, in regard to his future health, depends on his then possessing such ascendency of mind over body, of moral over animal feelings, as will ensure the establishment of wholesome habits of wisdom and temperance. The subjugation of gross appetites; the subordination of all turbulent or violent moral and mental emotions; the cultivation of the gentle and contemplative feelings best fostered in domestic life and in refined social intercourse; and the regular but moderate application of the intellectual powers to some definite object or set of objects worthy of pursuit;—these are elements of mental discipline which become the age of maturity, and if steadily cherished cannot fail to conduce, not only to the health and strength of both mind and body, but also to enduring comfort and happiness. It is true that many difficulties beset the beginner in his endeavours to follow such rules; many struggles arise against the inferior part of himself; much patience and forbearance is called for in regard to others; a constant practice of self-control is demanded in avoiding the temptations of excitement and intoxicating amusement; and incessant vigilance over the mind; to restrain it equally, from wandering into bye-paths away from its proper road, and from lapsing into desultory abstraction or indolence; and these impeding forces within, are too often prompted or seconded by no less formidable obstacles without, thrown up by the multitudinous and ever-rising allurements and trials of life—never absent at any time, but often peculiarly besetting its momentous unsteady commencement. Need it be said then that the efforts should be proportioned to the difficulties? and with the determined and rational exertion of human means, conjoined with humble and faithful dependence on more than human guidance and strength, such efforts will never prove unsuccessful in the end.

669. But it is more pertinent to our particular object to indicate the modes by which the mind and body reciprocally promote each other's health; and much in regard to this may be summed up in the Platonic axiom that these should be well balanced in their exercise and activity. The undue, or too prolonged, occupation of the mind with deep study or concentrated thought abstracts some of the supply of blood and of vital energies from the bodily functions; these consequently suffer and fall into weakness and disorder, whilst the nervous system, the material organ of the mind, becomes ultimately exhausted by the continued excitement, and refuses to perform some of its manifold functions; hence stupor, paralysis, or organic weakness of some kind may ensue; or there may be morbid erethism or irritation in the midst of general weakness; and delirium, spectral illusions, sleeplessness, tremors, and spasmodic or painful affections, may be the consequence. Mental idleness, on the other hand, not only weakens the intellect through disuse, but, by inducing habits of indolence and self-indulgence, pampers the body and perverts its proper functions, degrading them to an approximation to brutal or even vegetable life. Moderate and well-timed exercise refreshes the mental powers, and enabling them to apply with renewed vigour, increases their power and sphere of action. So likewise, pleasing mental impressions, such as are afforded by beautiful scenery, congenial associations, and interesting pursuits, heighten the benefits of bodily exercise, and give to all the faculties that re-nascent energy which is well expressed by the term *recreation.* A similar advantage accrues from varying the kind of mental occupation; thus music, drawing, amusing games, and light reading, are to many, more effectual than absolute rest, in refreshing the mind after severe study or close application. In like manner, intellectual tasks of different kinds may be profitably alternated with each other, just as the several muscles of the body may be beneficially exercised in succession (§ 664). Analogous rules too apply to the moral emotions, in so far as they can be placed under the direction of the individual; there is in most energetic minds a natural or habitual succession of high and low spirits, of lights and shadows in the mental hemisphere, which, however trying and hazardous when in excess, if occurring in moderation, gives to thought a renewed vigour which is wanting in minds of more perfect placidity.

SLEEP.

670. It would be altogether a work of superfluity to expatiate on the health-giving influence of a due amount of tranquil sleep. It is obviously the chief means which nature employs for recruiting the exhausted energies of the animal functions; and some of the causes and consequences of its failure have been already noticed as constituent elements of disease (§ 23, 56, 64, 154). Sleep appears to consist in a more or less complete suspension of the cerebral or sensorial functions, accompanied by an increase of the spinal and organic nervous influence; and we have suggested, that a modification in the distribution of the blood through the nervous centres may be instrumental in thus periodically reducing the activity of parts which are not essentially concerned in the maintenance of life (§ 153). The sensorial functions are, however, only impaired; they are not completely suspended, for a proof of their partial continuance during sleep is afforded not only in dreaming, but also in the voluntary movements, which are often performed to remove uncomfortable sensations, and even in the act of awaking when such sensations attain a certain degree of intensity.

The approach of sleep is announced by a sense of drowsiness, which consists of a dulness of sensation, perception, and thought, and of an indisposition to exertion. Gaping and yawning, although viewed as symptoms of sleepiness, really result from efforts to resist it: they seem to be movements designed to throw certain muscles, especially in the throat and neck, into a state of tension, during which the sensation of drowsiness is for the moment increased to a degree which is rather agreeable than otherwise, but which is speedily followed by its diminution. It is very probable that these movements tend to re-excite the slackening cerebral circulation, by momentarily impeding it, and then allowing it to flow again with augmented force; thus in a degree analogous to the hydraulic process of *flushing*. Sleep closes the relations of the senses to all moderate impressions from the external world, and suspends almost all voluntary movements, among which are to be reckoned those that are supplementary to the process of respiration (§ 628). The respiration is therefore rendered less frequent and more prolonged than when awake, and the pulse

is also lowered. The circulation and changes of the blood being thus reduced during sleep, there is also less power of maintaining animal heat; hence the chilliness commonly experienced, and the increased susceptibility to cold, unless the body is better protected than usual by clothing. Hence, too, the relaxation of the skin after slight febrile excitement, inducing perspiration, which commonly occurs first during sleep.

671. The circumstances which promote sleep are chiefly influences which impair the activity of the animal functions, and which withdraw all causes of excitement both from mind and body. A moderate degree of corporeal and mental fatigue; the absence of all uneasy sensations; a comfortable posture, affording the most complete rest to the limbs and voluntary muscles; freedom from the feeling of either hunger, thirst, or repletion, cold or heat; the recurrence of the usual hour for repose, and of the stillness and darkness of night,—are favourable to the induction of sleep. In addition to these agencies, which act negatively by excluding excitement, there are also others which often promote sleep, by causing gentle and monotonous sensations or ideas that have the effect of lulling into somnolence: such, for example, as the various expedients for hushing infants to rest, by rocking, patting the back, and singing, and with adults, gentle friction, reading, prosy talking, and other sensorial impressions, which slightly tire without exciting. These probably operate by diverting the attention from other occasional feelings or noises, which tend to disturb. The passes of mesmerism no doubt act upon this principle. The common plan of counting or reciting oneself to sleep, owes what little efficacy it possesses, to its abstracting the entire attention to an uninteresting object.

672. The influences which prevent or disturb sleep are for the most part the reverse of those above described. Any undue excitement or sensation of body or mind, whether of a painful or a pleasurable nature; strong, sudden, or startling impressions on the senses; uneasy postures; extreme fatigue or exhaustion; oppressed or imperfect breathing; palpitation of the heart; hunger, thirst, nausea, flatulence, and various other (often undefinable) sensations in the viscera; extremes of temperature; coldness of the extremities; irregularity in the habits of seeking repose;—these are the ordinary causes of sleeplessness. They operate either by directly exciting the sensorium to a degree

inconsistent with the suspension of its functions; or by so much reducing or disordering the power of the spinal medulla, that it is incapable of sustaining the respiratory movements without the aid of voluntary effort. In the former case positive pain, uneasy sensations, or exciting trains of thought, are present. In the latter there may be the desire to sleep, but no sooner does its commencement suspend the voluntary efforts by which the breathing is aided, than this process becomes imperfect, and the person starts with a feeling of oppression or impending suffocation, which is often embodied by an incipient dream into nightmare, or into the notion that he is being pursued by demons, or falling down a precipice, or undergoing some other horrible catastrophe. The sleepless hallucinations of delirium tremens, and similar disorders, in which continued excitement of the nervous system has exhausted the energy that is required in the medulla for the maintenance of respiration and muscular tone during sleep, are of this nature.

673. The loss of rest is so seriously detrimental to health, that it is of the utmost importance in a hygienic point of view that this result should be obviated; and besides avoiding, so far as may be possible, the several causes of wakefulness just specified, bad sleepers should strictly attend to the following directions for their regimen, rather than resort too hastily to hypnotic drugs, which, although sometimes useful and necessary as temporary expedients, lose their power by habitual use, and produce other evil consequences which render their long continuance improper.

Bad sleepers should make a regular practice of early rising: it may cost them some effort at first; but if they desire to have sound rest, they should seek it at the natural time, and not late in the morning when the excitements of the day begin. Their hours for meals and exercise should also be early and very regular (§ 644, 662); both in order to promote that state of health most conducive to ease and freedom from suffering, and also to secure the accomplishment of the processes of digestion, and consequent excretion or eructation before night, which is the proper period for repose (§ 643, 4). Exercise should be taken as freely in the open air as the strength will permit without causing lasting fatigue; and if walking or riding cannot be borne without such result, driving or sitting out in the open air several hours in the

day may often be resorted to as an efficient substitute; this acts by gradually and gently fatiguing the senses through the operation of light, air, and sound, whilst the organic energies are refreshed and invigorated by their salutary influence (§ 652). As the hour of retirement for rest approaches, every description of exciting agency should be avoided. The latest meal should be taken at least an hour before bedtime, and tea, coffee, and all vegetable matters apt to decompose in the stomach and generate gas should be excluded from it. Weak persons and others who are under the influence of fatigue, may often advantageously take a little wine or alcoholic mixture at this meal; its operation is to counteract the nervous excitement induced by exhaustion and weakness, and it so becomes composing and hypnotic (§ 64, 155). All active exertion, whether of body or mind, should be carefully shunned at this time. Conversation or reading should relate to common-place or tranquillizing subjects, which neither require much attention nor excite the feelings or imagination. The very preparation of undressing should be simplified as much as possible, and all superfluous proceedings, general washing, &c., should be postponed until the following morning. Much might be said about the arrangement of the bed and its appendages, and the posture best suited for tranquil repose; but it will be sufficient here to suggest that everything should be made as comfortable as possible, short of the risk of causing relaxation by excessive softness or abundance of covering. A soft upper mattress of hair, or of wool and hair, is always preferable to a feather-bed, not only because it is less relaxing, but also because it gives a more elastic and even support to the body and limbs, and prevents that sinking in of the body which fatigues a weak back by bending it. The posture that is generally most easy is lying on the right side, for this affords such support to the two weighty organs, the liver and heart, as obviates their pressing on the hollower viscera. The various expedients for inducing sleep, like repeating lines of poetry, and counting numbers, and other artifices, which act by diverting attention from exciting trains of thought, seldom succeed with the really wakeful. The plan devised by the late Mr. Gardner, and mentioned by Dr. Binns in his "Anatomy of Sleep," (p. 391,) has not proved more successful in my experience. It is founded on the same principle of abstracting the attention, by directing the mind to the imagined vision of the breath issuing

from the mouth during expiration. A proceeding, which I have found to answer better, consists in attempting to imitate the way in which a person breathes during sleep, by making the respirations, particularly the expirations, deeper and more prolonged than usual, and by giving to them somewhat of a sonorous character from the relaxed and imperfectly open state of the glottis. This often excites drowsiness, probably by gently retarding the return of blood from the brain; and this drowsiness may lead to sleep; but it frequently happens with this, as with all other voluntary attempts to procure sleep, that the continuance of the effort breaks the spell through the awakening influence of sustained attention; this objection especially applies to first attempts at practising such invocations of Morpheus. The expedient recommended by Dr. Franklin, for the restoration of sleep that has been broken, namely rising and shaking the bed, with the view to change the air enveloped in its coverings, is sometimes successful, particularly in hot weather.

674. The amount of sleep that is most conducive to health varies considerably with age, sex, employment, and constitutional and habitual peculiarities. Infants pass the greater part of the day as well as the night in sleep; and children, up to the age of six years, generally require at least twelve hours of repose, besides an hour or more in the middle of the day. At about this age, the sleep at noon may be discontinued, but the night sleep can hardly be abridged with advantage, until about the tenth year, and then only to a moderate extent, up to the period of puberty, after which it is for the most part proper gradually to reduce the period of rest to nine or ten hours; no further diminution beyond this is expedient until the cessation of growth, after which another hour or two may be taken away. The average amount of daily sleep that is beneficial in adult and middle ages may be stated at eight hours. In more advanced life the same extent of sleep is not less serviceable where it can be procured; but the capacity for sleep usually diminishes at this period, and wakefulness or disturbed rest becomes a common complaint of old age. Attention to the precautions recommended above (§ 673) will however often restore the capability; and, even if they do not sleep, aged persons should remain an increased length of time in bed, for the sake of warmth and rest, which their reduced calorific and muscular powers render more necessary than they once were.

Females commonly stand in need of more sleep than males; and during pregnancy and lactation additional rest is especially demanded, to assist the supplementary nutritive processes brought into operation in these conditions. In such cases, too, the loss of sleep is attended and followed by peculiarly injurious results to the nervous system and to the general nutrition, manifested in the form of mental derangement, impaired vision, deafness, paralysis, palpitation, convulsions, tremors, anorexia, wasting, diarrhœa, &c. Under these circumstances, it is a main object of treatment to procure sleep, and in addition to regiminal measures already suggested, nervous sedatives or hypnotics of the least depressing kind may be administered. Persons who are just convalescent from acute diseases, or who are otherwise weakened and reduced, require and generally obtain more sleep than in ordinary health, and it is so efficient an influence in the promotion of recovery, that artificial means are sometimes wisely adopted to ensure it. So, likewise, those who use much active exertion need a longer period of repose than those who are of sedentary habits; and the same may be said of persons who exercise their minds greatly; but as mental excitement does not dispose to sleep to the same degree as bodily fatigue, it is the more important that all persons whose intellectual powers are much strained, should also take such bodily exercise as may serve to maintain the balance, and to secure the due return of rest.

675. Salutary as the operation of sleep is at its proper time and in its due degree, it may prove injurious if indulged in to excess and at improper seasons. Too much sleep slackens the circulation, diminishes excretion and muscular nutrition, and causes general plethora or partial congestions, and in persons disposed to such a result, promotes the accumulation of fat. It also weakens the muscular and sensorial powers through the inactivity of their organs, and gives undue ascendency to the spinal function: hence it often leads to a tendency to spasmodic and other nervous disorders of the system, which may run on into fits of hysteria or even epilepsy. In persons liable to this class of disorders, an abridgment of the hours of sleep is often very beneficial; and this is best effected by gradually establishing the habit of early rising. Undoubtedly the most fitting time for sleep is the night, and although in temperate latitudes the nights are in summer too short, and in winter too long for the amount of needful

repose, yet the more nearly this is continued to the period when darkness and silence warn to rest, the better for the permanent comfort and well-being of the body. On the score of health, then, it is advisable that even adults should retire to rest, in summer especially, as many hours before midnight as can be spared after night closes; in order that they may be enabled to rise at or as soon after sunrise as the proper complement of sleep has been enjoyed. But, inasmuch as the usages of society and the business of life often establish unavoidable demands on the night hours of many persons, the compromise of retiring one hour before midnight should be enjoined for the sake of health, and accompanied with an exhortation to early rising, enforced by a description of the refreshing and invigorating influences of the morning air, with all its exhilarating concomitants of light and sounds.

EXCRETION.

676. The absolute necessity of efficiency in the processes of excretion for the maintenance of health has been incidentally illustrated by the numerous instances that have been cited in the preceding pages, in which their failure has led to the production of disease (§ 68, 248—254, 385, &c.); and although such instances have commonly been cases of disorder that have required the employment of medicinal measures, yet it must be borne in mind that the regularity and completion of the processes of elimination may be generally so far promoted by regiminal influences, that these deserve a place among hygienic agents. Depending, as excretion does, on the activity of the processes—of circulation, which furnishes the supply of blood to the secreting organs; of respiration, which maintains the essential properties of that blood by renewing its chief chemical agent; of assimilation, which adds to its materials; of muscular contraction, which effects the expulsion of the excrementitious matter; and of sensation, which takes cognizance of the need of its evacuation;—it might be anticipated that the proper performance of this office (excretion) will much depend on the vigorous condition of these several processes, which with it compose the sum of the general health. Hence many of the hygienic measures already recommended as contributing to sustain those several processes, are likewise efficacious in main-

taining due excretory power. Thus a proper regulation of *food*, solid and liquid (§ 642—644), and of *exercise* (§ 660—662), is one very important step towards favouring the excretions; and the functions of the skin and kidneys, and, in a less degree, those of the liver and intestines, are influenced by *clothing, temperature, air*, and *sleep* (§ 646—649, 652—655).

It will be sufficient here to enumerate a few of the most available measures that may be employed for regulating the action of the *bowels*, the *kidneys*, and the *skin*, during ordinary health.

677. No circumstance tends more to promote the proper action of the *intestines*, than the punctual habit of daily devoting a fixed and sufficient time to their evacuation. Medical writers have long insisted on the importance of punctuality in this: but they have not generally recognised the necessity of allowing a sufficient time for the proper completion of the act; yet with persons of costive habit this is far from being a secondary consideration. With individuals whose bowels act readily, an efficient peristaltic action forwards at the accustomed time the fæculent matter, in such consistence and quantity as is fitted for prompt and easy expulsion; but with those who have torpid bowels (and they constitute a very numerous class, even among healthy persons), the excrement is harder and the intestinal movement more slow, and instead of being all in the rectum ready for expulsion at the appointed hour, more or less of it is still commonly lagging behind in the sigmoid flexure, or even above it, and cannot be discharged by a momentary effort. Nor will violent straining (which is moreover injurious in other respects (§ 64, 289), properly aid in the process. Repeated gentle and sustained abdominal contractions, assisted, if necessary, by kneading pressure or friction downwards in the left iliac region, in the direction of the sigmoid flexure, with occasional variation in the position of the body, are the safest and most efficient means for accomplishing the object, but they require the sacrifice of a few minutes of time; and if the end were not worth this sacrifice, I would not trespass upon the delicacy of my readers by this allusion to so disgusting a subject. These expedients are more easy and natural, and less injurious than the employment of enemata; of which, even the simplest kinds, if habitually used, tend to injure the tone of the bowel, and to impair its natural action.

678. Other means may be mentioned as serviceable under ordi-

nary circumstances, in keeping up a regular and sufficient action of the bowels; such are the use of brown or rye bread instead of white; oatmeal porridge taken at night; revalenta or lentils; white mustard seed; stewed prunes; tamarinds; and baked apples; all of these operate by adding either a mechanical or a chemical irritant to the fæculent mass, and, therefore, may prove objectionable in consequence of irritating too violently or otherwise disordering the alimentary canal. The same may be said of the addition of toasted bacon to the breakfast, and of a quantity of fruit to the dinner. A more harmless, and occasionally more efficacious expedient, is found in drinking a large draught of cold spring water at first rising, and this is useful for other purposes likewise. With some persons malt liquors promote the action of the bowels. A walk before breakfast for the more robust, or a walk or ride immediately after that meal for others, often contributes to the same end; and in some instances such exertions as particularly bring into action the abdominal and other muscles of the trunk, as for instance, digging, and similar gardening occupations, prove more effectual.

679. Lastly, we must not omit mention of the habitual use of gentle aperient medicines, as the safest and most efficacious means for securing an adequate intestinal action in persons with whom sedentary occupations or other circumstances absolutely prevent the adoption of more simple hygienic measures for the accomplishment of the same purpose. Undoubtedly, it is preferable to avoid the constant use of medicine, if dietetic or regiminal management can be so conducted as to supersede the necessity for it; but long observation has convinced me that this cannot always be effected, and that then, as a prophylactic resource, a little daily pill is preferable to the practice of loading the stomach with fruit or other indigestible matter, with the object of stimulating the lower bowel. The drugs which commonly answer best as habitual laxatives, are rhubarb and aloes, both of which on account of their bitter properties combine somewhat of a tonic with their aperient influence. Aloes is the most efficacious, and if properly managed, does not lose its aperient power, even after many years of daily use. I know of one instance in which it was constantly employed for fifty-seven years, with unquestionably beneficial results, and the individual who took it, in spite of very sedentary habits, retained uncommon vigour both of body and mind until within a year of his death,

which occurred at the age of eighty-seven. By far the best mode of administering aloes as an habitual aperient, is in combination with a little mastich, and made into a mass with alcohol, which renders the pill less soluble in the stomach, and therefore more capable of acting on the lower part of the canal. The proportion which I commonly use, consists of three parts of watery extract of Barbadoes or socotrine aloes, with one of mastich powder, two or three grains of this is to be taken in the form of a pill at dinner or at bed time daily. This has no tendency to excite hæmorrhoids, provided an occasional dose of blue pill be administered to keep up a sufficient action of the liver. In several instances I have found it to operate more satisfactorily on joining to it a few grains of inspissated ox-gall. For weakly persons a grain of sulphate of iron or quinine may be also added with advantage.

680. The excretion of *urine* is less generally an object of solicitude than is that of the bowel, yet it is remarkable how commonly persons have their attention drawn to it, as they advance in years, often from experiencing discomfort in consequence of its irregularity or deficiency: such irregularities are undoubtedly an important element in a vast number of diseases, whether serious or trivial. It would occupy too much space to advert fully here to disordered excretion of urine; indeed the subject has been touched on in almost every part of the present work; it is only necessary, therefore, further to mention a few common hygienic influences by which the urinary excretion may be promoted or rendered free.

The quantity of urine, and consequently in a general way, its clearness and the lowness of its specific gravity, will be proportioned to the amount of fluid ingesta; but its increased flow is more certain to follow when fluid, especially if this be water, pure, or with a very slight addition of vegetable or animal nutriment, is taken on an empty stomach. Thus a large draught of spring water drunk at first waking in the morning, or an hour before dinner, is almost surely followed by a free flow of clear urine. The result, however, is promoted by such moderate exercise as excites the heart's action without causing perspiration. Some kinds of exercise peculiarly augment the secretion of the kidneys; especially such as bring the muscles of the loins into exercise, for instance, gardening, and trotting on horseback; these therefore

should be recommended to persons whose renal functions are defective, especially if they be liable to lithuria; for when the watery constituent of the urine is increased, the risk of any deposit taking place in the urinary apparatus is diminished. Similar means, if regularly employed, are useful also in gouty and rheumatic habits; and appear really to establish an increased elimination of solid matter, as well as of water, by the kidneys (§ 231, 257); in this respect their operation differs from that of medicinal diuretics, which unless very judiciously administered, excite for the time, and leave the secreting power exhausted afterwards. This is the chief objection also to certain diuretic beverages in common use, but as temporary expedients; such for instance as gin, Hollands, or whisky, diluted with water; spruce beer; imperial drink (water saturated with bitartrate of potass, sweetened and flavoured), leek or onion broth, barley-water, linseed and tamarind tea, and Seltzer water. Grapes, currants, and other ripe sub-acid fruits, are also occasionally serviceable in the same way.

681. The regular evacuation of the bladder, when it is distended to a certain degree, is prompted by the sensation which its fulness excites, but this happens variously in different individuals; some, either not feeling or easily resisting the inclination, and others yielding too frequently to the impulse. The latter habit is extremely inconvenient, especially on account of its disturbing the sleep at night; but the opposite custom of too long retaining the urine may also prove pernicious in various ways already hinted at (§ 68), and it should therefore be carefully avoided. In circumstances interfering with a proper observance of this caution, the urgency of the inclination may be diminished by limiting the amount of liquids swallowed, and by promoting the activity of the cutaneous excretion by means of warm clothing and external heat.

682. The objects of the *perspiratory* secretion are not entirely known; but its uses are recognised,—in evacuating from the superficial vessels superfluous water, acid, and oily matter, when they are distended or excited by the influence of prolonged heat or exertion; in tending to cool the surface thus heated by evaporation, and to remove the irritation of distension or obstruction; by relaxing the tissues; and through the same softening operation, in rendering the skin more pervious to the chemical action

of the air on the blood, and to the vital influences reciprocated between the blood and the tissues.

The excretion of the *skin* is, as has been mentioned, materially affected by *clothing*, *exercise*, *temperature*, and *air*; these agencies indeed are the chief means by which it is modified during health.

Other hygienic measures whereby the action of the skin may be promoted are bathing, washing, and friction. The chief operation of all these upon the skin is through its functions of circulation and secretion; and in proportion as they are freely used, they may extend their influences to the whole system. Thus warm bathing of the entire body, as it increases the amount and motion of the blood in the cutaneous vessels, and the perspiration from them, necessarily diminishes the supply to internal organs, and consequently the activity of their secretions. If continued long, or repeated frequently, general weakness is very apt to be induced, the surface remaining in a relaxed state. But the same objection does not apply to the occasional use of the warm bath, or the practice of daily washing the whole surface with tepid sponging or the shower-bath, followed by friction; these are highly salutary means, tending as they do to keep the skin in a free and active condition, and are well suited to persons of languid circulation. In the majority of healthy subjects, however, this object is better obtained by washing with cold water, and in the robust, even by the cold shower or plunge bath, which indirectly excites the functions of the skin by first constricting its vessels, and throwing the blood on internal organs, and then, through its impression on the incident nerves, by causing the excitement of reaction, which soon restores the superficial circulation in redoubled force, as indicated by the concomitant redness and glow (§ 80). This reaction is further promoted by vigorous friction of the whole surface with coarse towels or horsehair gloves, which operates not only by stimulating the cutaneous vessels and glands, but also by the muscular exertion exciting the heart to stronger and more frequent contractions; for the same reason a brisk walk after bathing is often useful. If after cold bathing the reaction is incomplete, and the skin remains pallid, chilly, and contracted, it may be inferred that the cold has been too long applied, that the cutaneous functions remain impaired, and that internal organs continue to be more or less congested. Or, if, after complete reaction, unpleasant sensations of fatigue, languor, chilliness, or headache, are expe-

rienced, this indicates that the cold has been too depressing or exhausting; in either of these cases tepid bathing or washing should be substituted. The vapour-bath, with its frequent accompaniments of shampooing and various aromatic and stimulant applications, although powerful remedial agents in disease (especially in cases of chronic rheumatism and its consequences), are too exciting and exhausting to be recommended as ordinary means to be adopted for the preservation of the health.

THE END.

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